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TO THOSE IN THE INDUSTRY WHO ARE ENGAGED ON SPECIAL WORK

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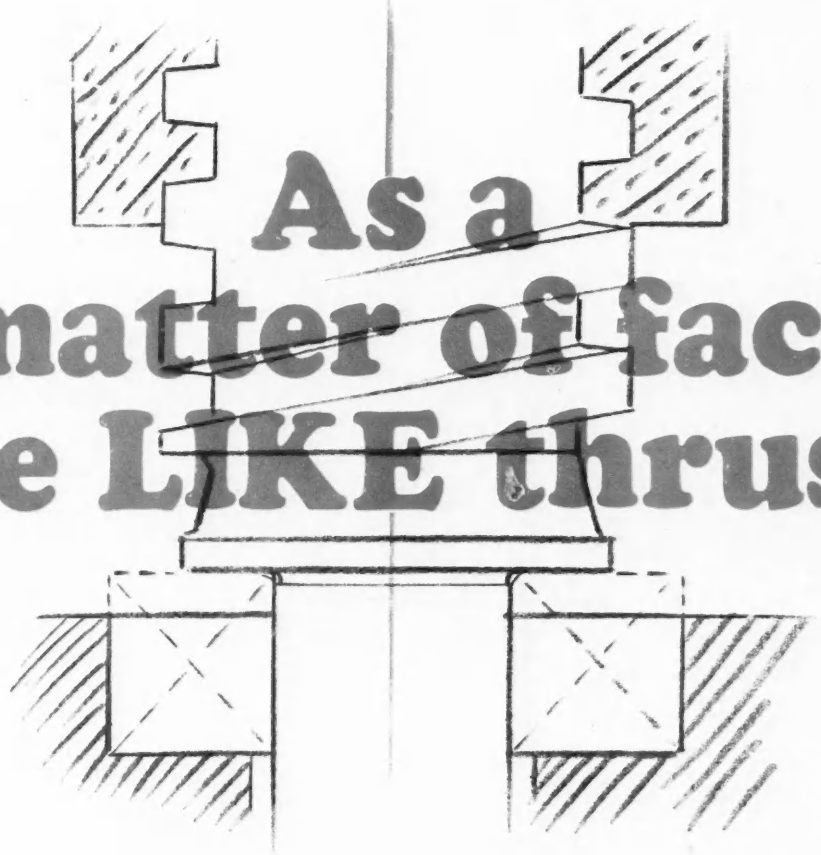

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The geometric taper principle, forming the basis of all Timken tapered roller bearings, makes it possible to resist thrust as well as radial loads. The long line of contact of the rollers, with their true rolling motion, means that the carrying capacity of these bearings is higher than that of other types of bearings.

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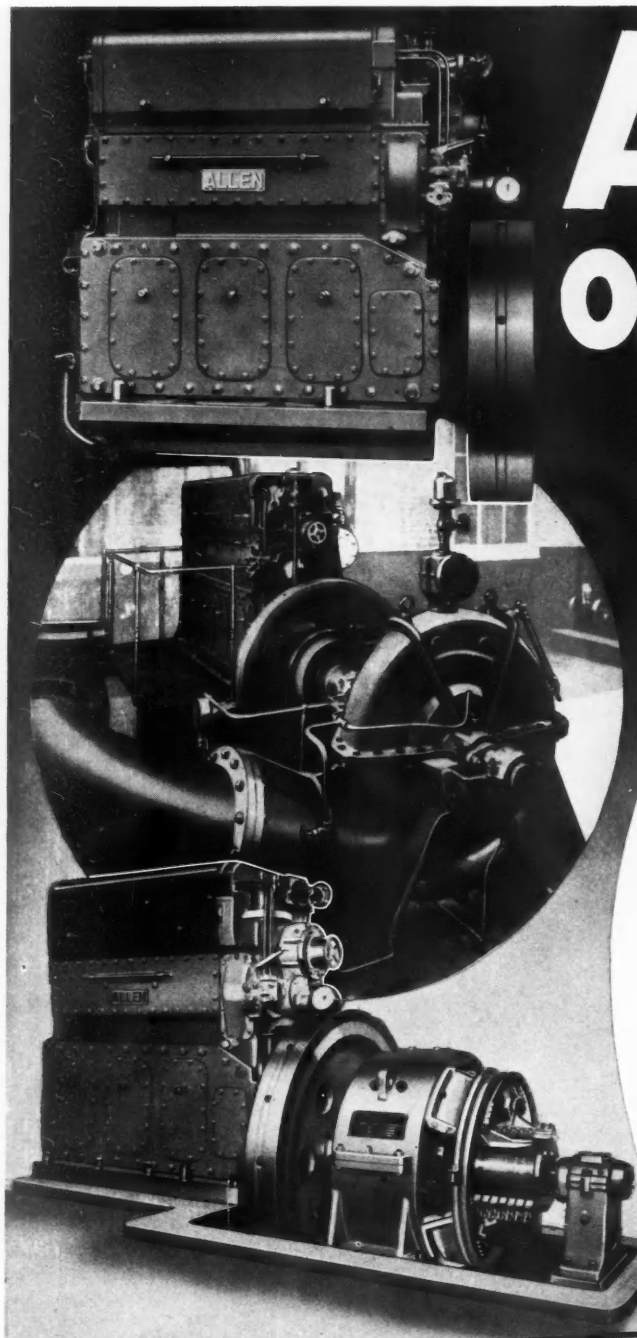

ILLUSTRATIONS

(Top) Typical 3-cylinder engine—type S30-B.

(In circle) 5-cylinder engine driving Allen drainage pump.

(Below circle) 3-cylinder engine coupled to an Allen D.C. generator for industrial power station.

(Bottom) 7-cylinder engine and alternator for municipal power supply.

Before the success of the airless injection engine had been established, the majority of oil engines worked either on the air blast injection principle or with crank-case compression and fuel injection into hot bulbs. Both these types had their disadvantages, and this Company was a pioneer in developing a medium speed solid injection engine.

The type S30-B engines illustrated are of the same bore and stroke as machines supplied in 1929, but have been entirely revised in design in order to give even better service than their predecessors.

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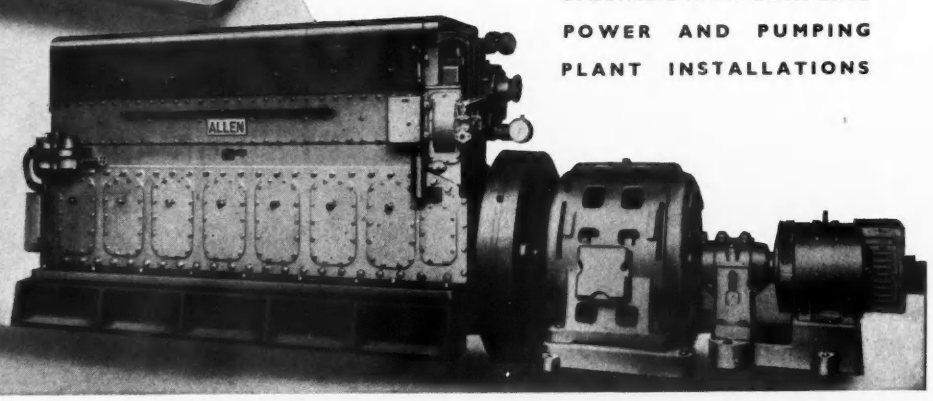

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A Seven-Day Journal

British Air Strength

SPEAKING in the House of Commons on Tuesday evening, August 20th, following Mr. Churchill's survey of the progress of the war, Sir Archibald Sinclair, the Secretary of State for Air, dealt with the work of the Air Ministry and the Royal Air Force. He said that the reorganisation at the Air Ministry had resulted in a direct representative of training being appointed to the Air Council. The work was still in its infancy, but the figures showed already a substantial increase in the flow of pilots from the service flying training schools. Substantial progress was being made with the Empire Air Training Scheme. They had expected to reach a certain figure of pilot production from Canada in July or August next, but they were now going to get that figure by April. The number of our fighter squadrons in the front line ready for operations against the enemy was, in spite of fighting which had been going on, higher that night than it had ever been. We were strengthening our bomber force, and the weight of our offensive was being felt ever more heavily in Germany and in Italy. The fact that the much larger heavy German bomber force was unable to inflict comparable damage on this country was due to our efficient system of defence. The Observer Corps deserved a special meed of gratitude. Our gunners and other ground defences, including machine gunners, had shot down 55 German aircraft since August 8th. Including that figure, our defence had accounted for 701 German aircraft during that period, mainly through the prowess of our fighters. We had lost 192 fighters and bombers. Our casualties in the air over this country and round our coast had been 90, compared with more than 1500 of the German crews. If there were included the bomber crews which we had lost over Germany since August 8th, our losses were much less than 300 and the comparable German losses were much more than 1500. Our night attacks were much heavier than our day attacks, and as the nights grew longer, so also would the arm of our heavy bomber squadrons lengthen, until we were striking ever deeper into the enemy's vitals.

Iron and Steel Control Appointments

THE Iron and Steel Control announces that Mr. J. M. Duncanson has succeeded Mr. Ralph Alsop as Deputy Controller of Steel Supplies under the Ministry of Supply. Prior to the outbreak of war Mr. Duncanson joined the Iron and Steel Control as Director of Heavy Steel, including semi-finished steel and shell steel. He was later appointed to the position of Assistant Controller of Steel Supplies. Mr. Duncanson is a director of The Steel Company of Scotland, Ltd., and deputy chairman of R. Y. Pickering and Co., Ltd. He is also on the board of the Glasgow Railway and Engineering Company, Ltd. These companies have seconded Mr. Duncanson, who has been given leave of absence so as to devote his services whole-time to the Control. In his new post he will be largely responsible for the control and distribution of steel supplies. The solution of many problems concerning steel supplies during a period when demand has inevitably tended to outrun production has been due in great part to his untiring energy and tact. Steel works and consumers alike have reason to be grateful for the helpful and constructive consideration Mr. Duncanson has given to their difficulties. It is felt that the continued smooth operation of the distribution scheme is ensured under the new Deputy Controller. Mr. Duncanson has been succeeded in the position of Assistant Controller of Steel Supplies by Mr. A. G. E. Briggs, who was formerly the Director of Alloys, Special Steel and Ferro-Alloys for the Control.

Metropolitan Water Board

AT a meeting of the Metropolitan Water Board, held on Friday, August 16th, Mr. Hugh Franklin, Chairman of the Works and Stores Committee, made a statement regarding the Board's preparations for a post-war programme. In giving preliminary consideration to a post-war programme, the Committee, he said, anticipated that there would be a hiatus in regard to employment between the demobilisation of the armed forces and the reorganisation of peace-time industry, during which period it would be the duty of every public authority to proceed with those works which had been in abeyance during the war. In order that the Metropolitan Water Board could make its full contribution towards that effort, it would be necessary for its plans to be in as advanced a stage as possible. The works which the Committee had in mind consisted mainly of the reconstruction and extension of existing pumping stations and filtration plant, the laying of new trunk mains and the completion of reservoirs commenced before the war; the problem of seeking further sources of water supply was being considered by the special committee recently appointed for that purpose, and that special committee would no doubt be giving early consideration to that important aspect of the Board's undertaking. Although the staff of the Board was already fully employed, the Committee anticipated that it will be possible to proceed with the plans of its proposals without additional personnel, so that by the end of the war each item of work would be as near as was practicable to the stage where tenders could be issued to contractors. To that end a preliminary schedule would be submitted to the next meeting of the Committee and reports thereon would be made to the Board when sanction for progress was required. Whatever the time at our disposal might be, that early preparation for the post-war programme would enable the Metropolitan Water Board to make its maximum contribution towards national reconstruction when hostilities had come to an end.

A Scottish Railway Accident Report

THE Ministry of Transport has just issued the report on the inquiry made by its officers, Mr. J. L. M. Moore and the Hon. H. T. de B. Bingham, into the circumstances of the accident which occurred at about 8.36 p.m. on March 5th, 1940, between Aviemore and Carrbridge stations on the Perth and Inverness single-line section of the London, Midland and Scottish Railway. It will be recalled that the 1.30 p.m. mineral train from Perth to Inverness parted owing to the failure of a drawbar hook at the entrance to Slochd crossing loop, which is at the summit of a steep gradient. The rear portion, consisting of twenty-one wagons and a brake van, after travelling backwards out of control for some 9½ miles, came into violent collision with the double-headed 2.45 p.m. freight train from Perth to Inverness, at a point about 2 miles north of Aviemore Station. The brake van and fourteen rear vehicles of the 1.30 p.m. train were wrecked, and three others were derailed and extensively damaged. The pilot engine of the 2.45 p.m. train was thrown over on to its side, and lay at right angles to the track beneath the wreckage, whilst the train engine remained on the rails and sustained but slight damage. Owing to the sudden stopping of this train when travelling at a speed of about 35 m.p.h., telescoping occurred near the front, and five vehicles were either totally wrecked or extensively damaged, while four others were derailed, with but little damage. The permanent way was torn up for about six rail lengths, and damage occurred to signal and telegraph equipment alongside the track. The driver and fireman of the overturned engine were killed, and the guards were injured. The inspectors state that the drawbar hook failed when the train was brought to a stand at the home signal, and was the result of a slight rebound due to the use of the brake. For the serious breakaway which followed, the guard of the train and the signalman at Slochd are held responsible. In the recommendations given in the report reference is made to the rapid progress made in the changing over of the material used for drawbar gear from wrought iron to steel, and the suggestion of the railway company to fit electrically operated catch points at a point sufficiently far north of Carrbridge Station to ensure that any derailment effected by them would not involve risk to the users of the public roadway immediately north of the station. The railway company is also considering the installation of these catch points on single lines where similar risks, resulting from long and sustained falling gradients, exist.

Railway Accidents in 1939

THE annual report of the Chief Inspecting Officer of Railways, which was issued on Monday, August 19th, shows that last year the liability of passengers to casualty in train accidents was one killed in every 171 millions carried and one injured in nearly 2 millions carried. With regard to railway servants, the passenger and freight miles worked were about 53 millions per fatality and 7 millions per injury. Casualties at public road crossings, including killed and injured, amounted roughly to one in 180 crossings. In train accidents, 9 passengers were killed and 795 injured, compared with 11 and 533 respectively in 1938, and with the annual average of 17 and 648 for the five years 1935–39. The fatalities which resulted from passengers attempting to enter or alighting from trains were 26, and those from falling off platforms and being struck by trains 16, these figures showing increases of 18 and 8 respectively over the returns for 1938. The total casualties to railway servants in train accidents were 8 killed and 59 injured, which compare with 7 killed and 62 injured in the previous year, and with the average of 10 killed and 78 injured for the period 1935–39. In accidents caused by or connected with the movement of railway vehicles, exclusive of train accidents, 78 passengers were killed, compared with 58 in 1938 and with the average of 69 for the period 1935–39. In similar movement accidents, 209 railway servants were killed, which figure compares with 193 in 1938 and with the average figure of 188 for the five previous years, 1935–39. Of the 217 formal inquiries held into accidents to personnel, 187 were of the movement class. As the result of these inquiries, 71 recommendations were made, of which 54 were adopted, others still being under consideration. In train and movement accidents combined the casualties among passengers, railway servants, and other persons totalled 358 killed, as compared with 321 for the previous year and with the annual average of 338 for the period 1935–39. The report refers to the record for 1939 as reflecting credit on both the travelling public and the railway staffs. The usual high standard of safety was fully maintained, notwithstanding the greatly increased pressure of traffic since the outbreak of war and the unusual operating conditions due to the black-out. The satisfactory results achieved were mainly due to the willing co-operation of railwaymen generally and their endurance and resource, and these, the report states, are worthy of the highest praise.

Spare Machine Tools

ON Thursday, August 15th, a letter was sent by the Minister of Supply, Mr. Herbert Morrison, to 20,000 firms in all parts of the country making an urgent appeal for second-hand spare machine tools, which, he asked, should be offered to him for immediate purchase for war production. In his letter Mr. Morrison pointed out that machine tools were urgently needed for the production of every essential armament, and that all machines not fully and usefully employed on war work must be directed to that end at once. There had been a machine tool census, and an inspection by officials of the Area Supply Boards. These measures had shown that the position was improving, but that there was still spare machine tool capacity which must be put to work. He pointed out, further, that the responsibility rested with the head of the firm to see that no machine tool which could be spared was retained. Plant which was being reserved for future contracts might well be placed at the disposal of the Ministry of Supply. It was necessary, Mr. Morrison said, for each works to re-examine its present machine tool operations, and to see whether by regrouping and replanning, the existing production could not be carried through with a smaller number of machines. If there were machines now engaged on the production of civil needs, other than those which were absolutely essential, Mr. Morrison invited owners to offer them to him for the use of the three Supply Ministries, on whose behalf he was making the appeal. On Tuesday last, August 20th, Mr. Morrison was in a position to state that nearly 3000 firms had responded to his appeal, and other offers from all kinds of firms were daily and hourly coming in. A number of the firms, including some of the very large ones, had informed the Minister that they were complying with his request to re-examine their machine tool operations, and were replanning their shops so that they might be able to spare the largest possible number of machine tools.

London Employers and A.R.P. Volunteers

THE Regional Commissioners for London have made an appeal to employers to assist in the arrangements which are now being made to enable trained A.R.P. volunteers to report for duty in the area in which they work. It is pointed out that while so far the German air attack on this country has been sporadic and largely ineffective, there is no reason to doubt that a much heavier and more widespread attack is being prepared. Whether at home or at work, it is vitally important that every trained worker should be at his post when the attack comes, be it by day or by night. Most of the part-time volunteers in the Civil Defence Services are enrolled for service near their homes. In the London area, however, it is the exception for people to work near their homes. The result is that the non-dormitory areas have relatively few volunteers to supplement the whole-time civil defence personnel. The situation in most non-dormitory areas is aggravated by the influx of a large day-time population of workers. Clearly it is desirable that trained volunteers who work away from home should be available to assist the Civil Defence Services near their place of work. People who are engaged in munitions or other essential work and A.R.P. workers of large firms are obviously exempt from these proposals, but this still leaves large numbers whose assistance would be most valuable. In order to be effective that assistance must be organised, so that local authorities, who are locally responsible for civil defence, must know on whom they can count. Volunteers must know their duty posts. A scheme to this end has recently been recommended by the Regional Commissioners to the local authorities. The Regional Commissioners for London therefore make an appeal to the employers in business areas to make appropriate arrangements to release trained A.R.P. volunteers among their staff to take up duty during an air raid.

The Delaware Aqueduct, New York

No. II

(*Continued from page 102, August 16th*)

BROADLY stated, the sinking of well-nigh all of the shafts for the Delaware aqueduct has followed virtually standardised present-day practice, where ground conditions made that course practicable. In a few situations, faulty or otherwise troublesome rock necessitated altered procedure. In one other shaft, a novel course was followed in getting down to tunnel grade, and that was resorted to because the initial shaft had to be much enlarged ultimately and valuable time could be saved by utilising was buoyed by 168 steel drums of 50-gallon capacity. There was an inner templet centrally located within each main templet, and the smaller templet carried a timber working platform, the buoyancy of which was augmented by twenty-four steel drums, each of 50-gallon capacity. The piling was driven by tractor-mounted cranes equipped with 105ft. boom and driven by 160 H.P. gasoline engines. Cell construction was advanced simultaneously from each of the wing earth embankments. Each section of embankment quently has been advanced by taking out the entire tunnel section in one operation. This has been made possible by the well-nigh uniform mechanisation of the work in drilling, mucking and the handling of the muck trains, for example. The practice is to mount the air-driven rock drills on some form of carriage or jumbo, and the mountings at the front end of such a carriage permit the simultaneous use of from five to nine drills, the number varying with the excavated diameter of the tunnel section and also with the number of holes drilled for each round in meeting the changing nature of the rock encountered. Virtually all contractors driving sections of tunnel for the aqueduct make use of electrically driven Conway mucking machines to load the cars of the muck trains. Some of the contractors have adopted rather complicated "grasshoppers" for the dual purposes of passing muck cars and for carrying

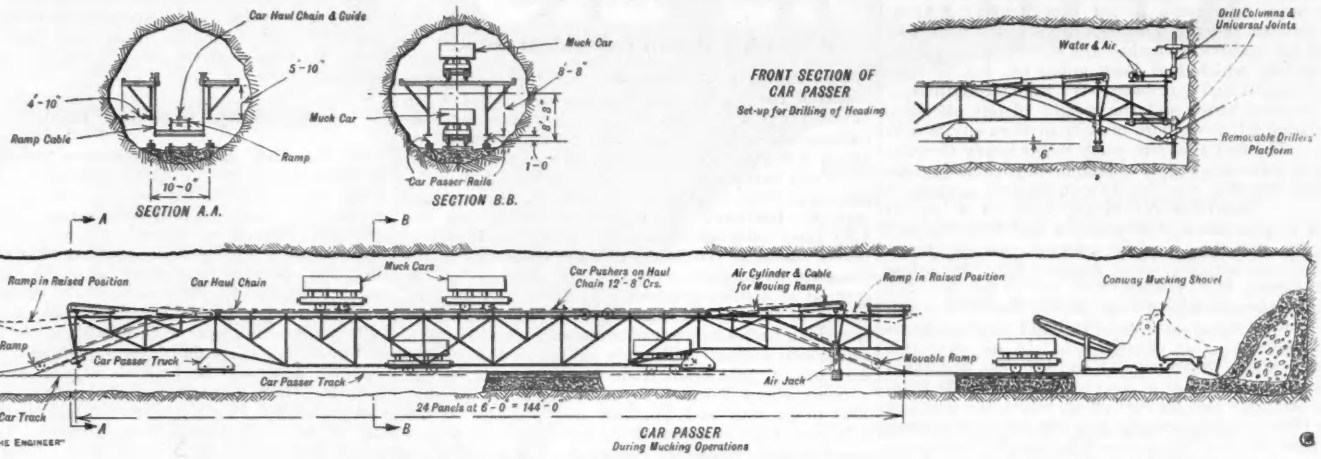


DIAGRAM OF TUNNEL DRIVING PLANT

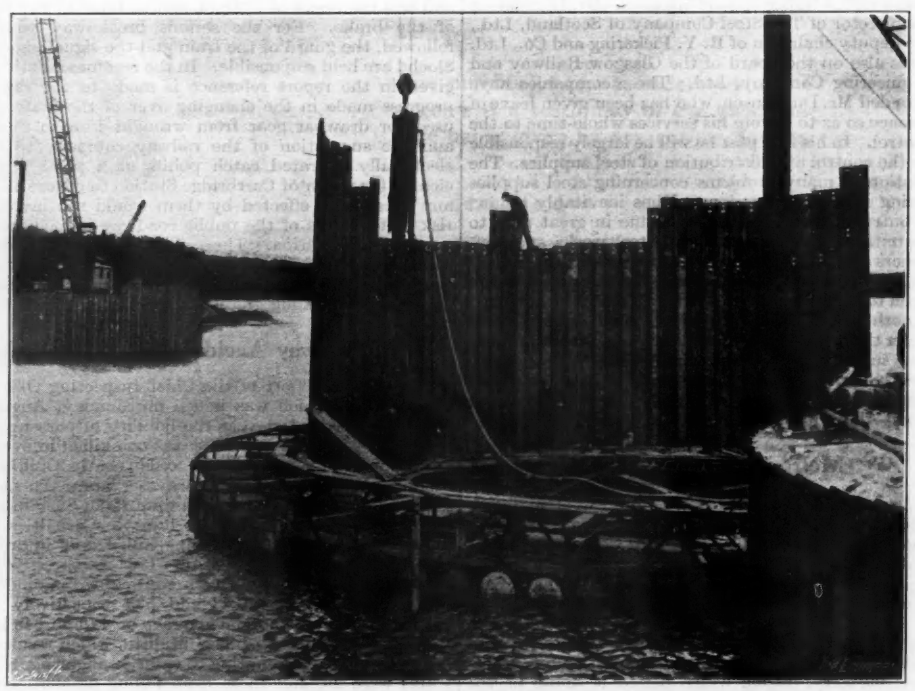
unusual facilities. Apart from depth, the various shafts differ in their diameters and forms depending upon whether they were sunk merely to facilitate tunnel driving or to serve permanently for one purpose or another. All shafts were sunk under separate contracts before any contracts were awarded for tunnel driving.

Shaft No. 13 is to serve as a drainage shaft for the West Branch–Kensico tunnel, and it is approximately elliptical in cross section in its finished state, and measures 26ft. 4in. by 23ft. 4in. The shaft is offset 100ft. to the east of the centre line of the tunnel. An access drift connects the bottom of the shaft with the tunnel, has a length of about 110ft., and intersects the tunnel at right angles. The contractor elected, at his own cost, to excavate and to line in the usual manner an auxiliary construction shaft, 14ft. in diameter, situated on the centre line of the tunnel and about 66·3ft. south of the centre line of the access drift. Shaft No. 13 *a*, for as such the 14ft. shaft is known, expedited the start of work on the tunnel and, incidentally, obviated the handling of tunnel muck and tunnel concrete through the small dead-end drift. The sinking of shaft No. 13 and its enlargement could then proceed without in any way hampering tunnel driving and be independent of it.

At Kensico reservoir there are four new shafts that form part of the Delaware aqueduct. Shaft No. 17 uptake and shaft No. 17 downtake are on the east side of the reservoir, and shaft No. 18 uptake and shaft No. 18 downtake are on the west side of the reservoir, and one of these groups is close to the shore while the other one is offshore. Provision had to be made in each case to shut out the water of the reservoir so that the work of sinking the shafts could be carried on without polluting the water continually drawn off from the basin. The more interesting of these jobs of isolation was in connection with the sinking of shaft No. 18 uptake and shaft No. 18 downtake. A cofferdam having a total length of 960ft. was built to enclose an area adjacent to the west shore of about 320,000 square feet within which was thus impounded 40,000,000 gallons of water. The central section of the dam was formed of thirteen circular cells, each 50·9ft. in diameter. Each cell had a perpendicular wall built of straight web-type steel sheet piling weighing 43·8 lb. per linear foot of pile. Each cell was filled with earth, and earth embankments formed the wing sections that tied the cells to the opposite shores.

Floating templets were used to guide the piles during the construction of each cell. Each templet was stiffened by a central line or core wall of piling. The top of the cofferdam is 7ft. above the normal flow line of the reservoir, has a maximum clear water depth of 53ft., and penetrates the bed of the reservoir to depths ranging from 15ft. to 30ft. All told, 2055 sheets of piling, from 30ft. to 85ft. in length, and weighing 5,270,000 lb., were used in the construction of the dam. The impounded area was unwatered in two stages by centrifugal pumps having a combined capacity of 2000 gallons per minute. A cofferdam of lesser extent, but of the same general design, has been built at West Branch reservoir for the sinking of the uptake and the downtake shafts at the north and south shores of that basin.

With the exception of the short lengths of tunnel driven 200ft. in each direction from the bottom of each shaft by the shaft contractor—where the excavating was done by the top heading and bench method—virtually all other tunnel driving subsequently has been advanced by taking out the entire tunnel section in one operation. This has been made possible by the well-nigh uniform mechanisation of the work in drilling, mucking and the handling of the muck trains, for example. The practice is to mount the air-driven rock drills on some form of carriage or jumbo, and the mountings at the front end of such a carriage permit the simultaneous use of from five to nine drills, the number varying with the excavated diameter of the tunnel section and also with the number of holes drilled for each round in meeting the changing nature of the rock encountered. Virtually all contractors driving sections of tunnel for the aqueduct make use of electrically driven Conway mucking machines to load the cars of the muck trains. Some of the contractors have adopted rather complicated "grasshoppers" for the dual purposes of passing muck cars and for carrying removable platforms at the front ends for the mounting of drills, while others place wider dependence upon more compact mobile structures, known as "cherry pickers," which serve as drill platforms, car shifters, and underpasses for the muck trains. Wet drifter drills are used throughout to minimise the dust count, in accordance with a law passed some years ago by the State Legislature of New York. Also as a further dust control measure, large ventilating plants have been



STEEL PILE CELLULAR COFFERDAM IN KENSICO RIVER UNDER CONSTRUCTION

required under each contract. According to an official statement made in April of this year, the average rates of progress in typical nine-week periods under different ground conditions at a heading was as follows :—13·5ft. tunnel in generally favourable ground, about 200ft. per week ; 15ft. tunnel in more difficult ground, about 140ft. per week ; 19·5ft. tunnel in more difficult ground, about 125ft. per week.

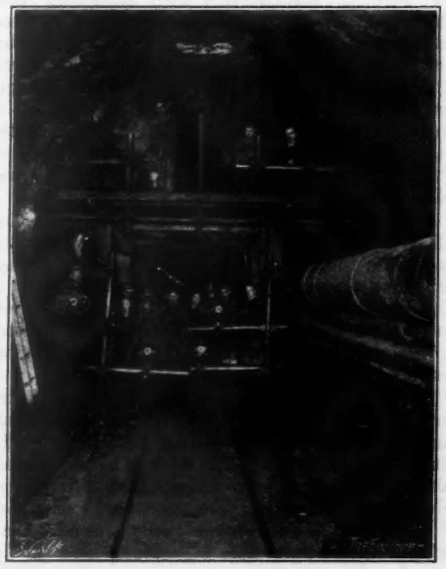
While all the present work is scheduled to be

finished not later than 1945, the prevailing opinion is that the time set will be anticipated. Work is being pushed especially on the tunnel sections between the West Branch reservoir and the Hill View reservoir, so that 100,000,000 gallons of water daily may flow by gravity to the Hill View reservoir from the West Branch reservoir that is located in the higher section of the Croton watershed. To-day, any Croton water reaching the Hill View reservoir for distribution is delivered there only by pumping the new Croton aqueduct where it passes the Hill View reservoir, being 160ft. lower than the reservoir.

The planning of the Delaware water supply for New York City, and the protracted litigation with the states of New Jersey and Pennsylvania for the use of the head waters of the Delaware River originating within the State of New York, owe their successful conclusions to the guiding work of Walter E. Spear, late Chief Engineer of the Board of Water Supply of the City of New York. We regret to have to record that while this article was still under preparation Mr. Spear died on March 29th of the current year. His loss to the organisation with which he was long identified, to the members of his profession and to the people whom he has benefited is deeply felt. Charles M. Clark, formerly Deputy Chief Engineer, has now become Chief Engineer of the Board of Water Supply of New York City.

RONDOUT - WEST BRANCH TUNNEL

HEADFRAME AT SHAFT 4



"CHERRY PICKER"

Links in the History of the Locomotive

THE FIRST FOUR-CYLINDER LOCOMOTIVE, 1825

By E. A. FORWARD

No. II

(Continued from page 109, August 16th)

TURNING now to the actual lay-out of the cylinders and valve chests on the reconstruction drawings, it was found necessary to inset the valve chest behind the centred plane of the cylinders in order to allow the crosshead guiding rods and the connecting-rod to pass in front of it and its steam ports. It was found possible to fit them in with the valve chest just touching the boiler lagging, while keeping the cylinder centres 5ft. 6in. apart transversely, which was the distance given by Hackworth in his designs.

For the design of the cylinders and valve chests much help was obtained from a drawing discovered by Monsieur F. Achard, amongst the records of the P.L.M. Railway, and believed to have been acquired by Marc Seguin, probably on his second visit to England between December 9th, 1826, and February 3rd, 1827 (see Newcomen Society "Transactions," Vol. VII, Plate 13). This drawing shows an engine with its cylinders standing vertically on the end of the frame, and driving the nearest pair of wheels through half-beams and connecting-rods, somewhat in the manner adopted by Rastrick for his "Stourbridge Lion" and "Agenoria," but with roller-guided crossheads, instead of parallel motion. The curious point about this design is that the cylinders are furnished with piston valves, and this suggests a connection with Messrs. Taylor and Martineau, or with Wilson, who may have had some connection with them. As in September, 1827, Wilson offered to make another engine for the Stockton and Darlington Railway, it is possible that this drawing represents his second design. It may also be noted that this cylinder and beam arrangement is closely like that of Hackworth's third design shown to the Prussians in 1827.

It was found that the valve chest from this design combined well with the pair of 6in. cylinders and fitted perfectly the required conditions. The vertical location of the cylinders was more or less automatically determined by the necessary relative positions of the boiler, driving wheels, valve chest, crosshead, and excentric shaft.

The position of the cylinders having been settled, the question of their mounting arose. They might have had arms cast on them by which they could be bolted directly to the boiler barrel, or they could be supported on brackets attached to the engine frame and boiler. As the lower end of the cylinder came close to the top edge of the adjacent boiler support, it appeared to be a simple and convenient arrangement to add a horizontal plate to the boiler support on which to stand the cylinder. This scheme is preferable to the former one, in one respect, as it permits more accurate location of the cylinders, and has therefore been adopted, although it involves duplication of the boiler supports at that end. A disadvantage of this arrangement, at least to modern eyes, is the difficult access to the cylinders for piston packing renewals, but this was a defect common to most of the engines of the period.

The reason for Wilson's use of the peculiar method of guiding the crossheads is not clear, as obviously if the sliding rods had been fixed to their guide brackets, and the crosshead allowed to slide along them, then nearly half the length of the rods might have been saved. The arrangement did, however, give increased lateral rigidity in the plane of the piston-rods, equivalent to that obtained by the use of very long crosshead slippers, and would thus guard against any tilting of the crosshead. The lower brackets for the sliding rods can be fastened conveniently to the top cover of the valve chest, while the upper brackets have been mounted on bar tripods with their feet bolted to the boiler and the cylinder covers.

As Wilson's factory was in Forth Street, Newcastle, and therefore very close to the Stephenson works, it may be supposed that he was acquainted with the engines being made there, and he was evidently well aware of the performance and trials of the Killingworth engines. Possibly, also, the Stephensons were aware of what Wilson was doing. This raises a question in relation to the valve gear. While it is believed, from the earliest description, that Stephenson's Stockton and Darlington engine "No. 1" had its valves driven by a loose excentric on one of the axles, the three succeeding engines had a separate transverse excentric shaft across the top of the boiler and driven by end cranks from the mid points of the coupling-rods. This arrangement, it may be noted, was the only one described by the Prussian engineers, which leads one to think that perhaps all four engines had this gear at first. They described it as simple and cutting out many valve rods.

Now Wilson's gear was of the same type and we may well ask—did he copy it from the second Stephenson engine, which was delivered in November, 1825, or did Stephensons copy Wilson by having a knowledge of his engine when under construction?

Hackworth was evidently partial to this gear, as he carried it on to his "Royal George"; in fact, he may have utilised such parts of Wilson's gear as were suitable and sufficiently robust for working flat slide valves instead of piston valves.

With regard to the details of the valve gear, Seguin's sketch clearly shows that the excentric rods were horizontal and that the valve spindles appeared to cross them at right angles; but he gives no hint as to the actual connection. The

valve spindle could hardly be directly connected to a point on the excentric rod itself.

The most probable arrangement is similar to that shown on Rastrick's sketch of the "Royal George," where the equivalent of a bell-crank lever was inserted between the end of the excentric rod and the valve spindle, to convert the horizontal motion of the former into the vertical motion required by the latter. Such an arrangement, with the valve countershaft over the end of the excentric rod and the horizontal bell-crank arm returning towards the excentric, does, in fact, fit in very well with the adopted positions of the various parts, and gives roughly the appearance depicted by Seguin.

It is assumed that the excentric rod ends could be detached from the countershaft arm pins, and handles would be provided on the countershafts so that the valves could be worked by hand when starting or reversing. The piston valves themselves had inside steam admission and were hollow, so that only one exhaust port at the top of the valve chest was required.

A foot board is mounted above the wheels on each side, and a seat is provided for the driver on the near side, from which he could conveniently reach the valve gear and the steam-regulating valve.

The cast iron end plate of the boiler would, no doubt, following Trevithick practice, have flanges cast on it to which the ends of the flue tubes were riveted. It is shown bolted, by means of an angle-iron ring, to the end of the barrel to facilitate the removal of the flues for cleaning or repair. The chimney is placed on the left of the fireplace to agree with Rastrick's sketch of the "Royal George."

The wheels have been shown with eight spokes, that being the usual number shown on the wheels of the Killingworth engines. The Prussian's description of the improved two-part wheels, seen early in 1827, stated that they had twelve spokes, and the wheels of later illustrations seem to show that that number afterwards became common. Rastrick's sketches of January, 1829, however, show both the "Royal George" and "Experiment" with eight-spoked wheels, while Tomlinson quotes documentary evidence that Messrs. R. Stephenson and Co. were making eight-spoked wheels for Hackworth in August and November, 1828.

Other necessary details of the engine have been designed as nearly as possible in accordance with contemporary locomotive practice and require no comment.

No definite reason has been given for the non-success of Wilson's engine, but the boiler was evidently a good one and capable of meeting Hackworth's requirements in the matters of pressure and steam production. How long the engine actually worked is uncertain, but the company's records, quoted by Tomlinson, show that it started work in December, 1825, and during the first three months of 1826 it hauled a little more than 1000 tons of coal, for which service Wilson was paid at the usual rate. The engine was therefore not entirely useless and was probably employed at least until the arrival on the line of more Stephenson engines in April and May, 1826.

Now the four cylinders, 6in. diameter by 20in. stroke, equivalent to two cylinders 8·5in. diameter, had a volume only 0·75 of that of the two 9in. by 24in. cylinders of the Stephenson engines, and if the same steam pressure was used this was probably a sufficiently serious defect to account for its failure. If, however, Seguin's statement that its steam pressure was only 30 lb. per square inch is correct, then its pressure × volume capacity would be less than half that of the Stephenson engines. The writer, however, is inclined to doubt the correctness of Seguin's pressure figure, as the Killingworth engines certainly used steam at 50 lb. pressure, and that pressure was continued in the Stephenson engines on the Stockton and Darlington Railway.

Another possible cause of trouble might have been its weight. This has been calculated and is found to approximate to 6·9 tons light and 8·75 tons in working order, of which 3·95 tons came on the driving axle and 4·8 tons on the other axle. In order to equalise the weights on the two axles it would be necessary either to set the boiler 4·5in. forward in relation to the cylinders and wheels, or to move the rear axle 8in. further from the driving axle. It appears to the writer that the latter alternative is better, and that probably the original wheel base was 6ft., a length more in accord with Seguin's sketch than the figure tentatively adopted.

Now "No. 1" and the other Stephenson engines weighed not less than 8·25 tons in working order, while the "Experiment" when it appeared in January, 1828, as a four-wheeled engine, must have weighed over 9 tons. The latter engine was, however, laid off as being too heavy for the rails, which it bent and broke, and there is evidence that there was too great a proportion of its weight on the axle at the cylinder end.

The working weight of Wilson's engine, therefore, came between these two, while its unladen weight was below the limit of 7 tons set by the company in November, 1827, so although perhaps near the permissible limit nothing has been recorded against it in this respect. It is likely, therefore, that the main reason for its failure was the low cylinder power, coupled possibly with a lack of robustness in some of its working parts, or perhaps defective operation of its piston valves.

Wilson's engine was reconstructed by Hackworth, in the manner previously indicated, during the middle part of 1827, emerging as the "Royal George," which started work on November 29th of that year. Its cost is said to have been £425, this figure presumably including the cost of the original engine, which was put at £380; but if the latter price was actually paid, only £45 would be left, which seems hardly sufficient to pay for the new cylinders and other parts, boiler alteration, &c. It may be noted here that the first Stephenson engines cost £600 each, including tender.

Timothy Hackworth's historians have stated that the cylinders of the "Royal George" were made by John Wight, of Lumley Forge, but a fire at Wight's works destroyed the patterns, causing some delay while others were being prepared. This tale seems to be doubtful, as we have T. Hackworth's own statement that the S. and D. Company bought of R. Stephenson and Co. one cylinder, 11in. diameter, on September 28th, 1827, which must have been for the "Royal George." Messrs. Stephenson's old ledger confirms this, and also shows that they supplied, in August, 1827, two other cylinders of exactly the same weight, and, therefore, most probably of the same size and for the same engine. The cost of these three cylinders was £15 13s. 1d.

The "Experiment" locomotive, after being laid off as too heavy, was rebuilt with six wheels and springs in the latter part of 1828, and after it had returned to work a Sub-Committee Minute of October 31st, 1828, approved of the great improvement made in it, while T. Hackworth was directed to make the same improvement in all the engines as early as possible.

Now, Tomlinson pointed out that this Minute implied that the company, at that time, had only one six-wheeled engine at work, as the earlier Stephenson engines did not require six wheels, although they might have been fitted with springs. He therefore asked the pertinent question: "Was the 'Royal George' only placed on six wheels after that date?" Now, this doubt, whether Hackworth's engine was at first a six-wheeled one, had never to the writer's knowledge been expressed before, but it was quite reasonable, as the change to six wheels might have been made between October, 1828, and January, 1829, the date of the earliest known illustration of it. The rebuilding of Wilson's engine might thus have been carried out in two steps.

The fact that Hackworth's designs shown to the Prussian engineers covered both a four-wheeled and a six-wheeled version of his inverted cylinder arrangement certainly indicates that his chief aim was to increase the cylinder power, and, as put into effect, his new 11in. by 20in. cylinders had a volume 25 per cent. greater than that of the Stephenson engines.

Hackworth in his notebook, under date October 30th, 1827, refers to an iron water box bought from Messrs. R. Stephenson and Co. for the "new locomotive with six wheels." This seems to settle the question, but it is worthy of further examination. Now, the crux of the matter would be whether he could fully utilise the tractive power of his cylinders with the weight of the engine when on four wheels, and this point will now be investigated.

The maximum tractive effort of the Stephenson engines was 2250 lb., with a steam pressure of 50 lb., and with their weight of 8·27 tons this gives a tractive effort to weight ratio of 0·122, which meant that the engines could work without slipping in fairly bad weather conditions. If Hackworth intended to adopt the same adhesion ratio for the "Royal George," with its maximum effort of 2800 lb., then the engine weight should have been 10·3 tons.

We have seen that Wilson's engine weighed 8·75 tons, and if we assume that the cylinders only were changed, it is estimated that the weight would be increased to 9·5 tons. While this would have permitted the engine to work with an adhesion ratio down to 0·14, it would, judging by the "Experiment," have been too heavy for the rails, so we may take it as certain that the engine was put on six wheels at once, without passing through an intermediate four-wheeled stage.

By calculation, lengthening the boiler, adding a new axle and wheels, coupling rods, &c., would bring the weight up to 11·25 tons, and therefore well above that necessary for the cylinder power. When Rastrick saw it in January, 1829, its weight was 12·38 tons in working order. The extra weight may be accounted for by new wheels, the springs, and perhaps more water in the boiler.

The "Royal George" started loading coals on November 29th, 1827, but it had not worked for long when T. Hackworth recorded in his notebook: "Wm. Golding, 'Royal George' engine, on the evening of Dec. 13th, 1827, coming up the line with 20 waggons, the ring round the fire tube gave way 2 feet in length. He put the waggons into the siding. This engine was set on the line a fortnight before, made a journey each day, one journey to Darlington with 24 waggons, and can gender steam to propel the waggons well" ("Timothy Hackworth and the Locomotive," by Robert Young).

Now, this giving way of the ring round the fire tube suggests that part of the cast iron flange, to which the furnace tube was riveted, broke away from the plate. If so, to make a good repair might necessitate cutting off the remainder of the flange and replacing it by a wrought iron angle ring. This probably accounted for the length of time, five weeks, taken by the repairs. Hackworth noted, on May 2nd, 1828, that a boiler plate was wanted for the boiler end of the "Royal George," so that he was evidently about to replace the cast iron end plate entirely.

Now that we know the real form of Wilson's engine it becomes apparent that the design of the two locomotives, sent to France for Marc Seguin in March and April, 1828, was directly derived from Wilson's by a kind of inversion of its parts. In Wilson's engine there were, on each side, two cylinders with a single connecting-rod between them driving one axle, while in the other design there was one cylinder between the wheels with a connecting-rod on each side of it, so driving the two axles. This appears, in some ways, to be a superior arrangement, as it permits the cylinders to be placed lower, where they could be securely fastened to the frame, and gave a more equable weight distribution.

It is not known with certainty when this design of locomotive first appeared, and it does not appear to have been used in England except for the two engines sent to Seguin. There is a distinct possibility that it may have originated with Marc Seguin himself, and this supposition might well account for the fact that he adopted exactly the same design for twelve of the locomotives with tubular boilers which he built for the St. Etienne-Lyon Railway from 1829 onwards.

We see, then, that Wilson's locomotive of 1825 is of historical importance, not only as being the first four-cylinder railway locomotive, but also as the first engine in which a single axle, with cranks at right angles, was driven directly from the piston crossheads, this being a distinctly notable step in the improvement of the locomotive. We have seen also that it led to further developments.

Of the man himself little is known, but, as already stated, Tomlinson connects him with the Newcastle Trevithick locomotive of 1805. Old Newcastle directories show that a Robert Wilson, Whitesmith and Bellhanger, was in business in Back Lane, Newcastle, in 1811. In 1824 his works were in Forth Street, and he was then described as a "Smith and Steam Engine Builder." His name last appears as "Engine Builder" in Forth Street in 1847.

The writer is indebted to the Council of the Newcomen Society for the reproduction of Seguin's sketch of Wilson's engine; to Robert Stephenson and Hawthorns, Ltd., for the use of information from the old ledger of 1823–1831; and to Mr. A. N. Appleby Miller, of the Newcastle Public Library for his search in the old directories.

Stabilising Effect of Passive Resistance on Underground Arches

By J. D. W. BALL, Assoc. M. Inst. C.E.

At the present time many underground shelters and storage chambers are being constructed, the design of which presents some difficulty owing to the lack of reliable data for computing the pressures to which the structures will be subjected. Many of these works require at least 50ft. of cover, and are constructed by tunnelling into the side of a hill. Under these conditions a brick arched roof provides a convenient type of construction, and the selection of the thickness of the arch is largely a matter of rule of thumb, arising from established practice. When the stresses in such arches are analysed on the basis of the unsymmetrical pressures which are frequently encountered, there appears to be at first sight a very small margin of safety. A factor tending to increase this, which some engineers take into account, is the passive resistance of the material on the lightly loaded side of the arch.

Even when tunnelling in good rock, falls of 5ft. have been known to occur, and with somewhat softer material greater falls up to twice this amount. In the case illustrated, which is an arched roof of 26ft. clear span and 7ft. 6in. rise, a fall of 9ft. has been assumed in the form of a parabola, with its axis excentric to that of the arch, so that one half of the arch supports a load of 9ft. of material and the other half a load tailing off from 9ft. at the crown to practically nothing at the left abutment. The unsymmetrical squeeze encountered in inclined laminated strata produces much the same effect. The arch is assumed to be subjected to these vertical loads, and to the active lateral pressure of the fallen material, which is calculated from Rankine's familiar formula $w\,h\,(1-\sin\theta)\div(1+\sin\theta)$. The angle of repose of the compressed material is assumed to be 66 deg. and the weight, allowing for moisture, 155 lb. per cubic foot. The centre line of the arch, which is composed of five half-brick rings, has been divided into sixteen equal parts, and the loads acting upon each of these divisions, excluding the weight of the arch itself, are tabulated in Table I, and represented graphically in Fig. 1*b*:

TABLE I.—*Superimposed Vertical Loads and Lateral Pressures per Foot Run of Arch*

Division No.	Depth of load in ft.	Vertical load in tons per sq. ft.	Width of division in ft.	Total vertical load, tons.	Horizontal pressure in tons per sq. ft.	Area in sq. ft.	Total horizontal pressure, tons.
1	1·0	0·07	1·2	0·08	0·0032	1·8	0·006
2	2·0	0·14	1·4	0·20	0·0064	1·7	0·011
3	3·0	0·21	1·7	0·35	0·0096	1·5	0·014
4	4·2	0·29	1·9	0·55	0·0132	1·2	0·016
5	5·2	0·36	2·0	0·72	0·0164	0·9	0·015
6	6·5	0·45	2·1	0·95	0·0205	0·7	0·014
7	7·3	0·51	2·1	1·07	0·0232	0·5	0·012
8	8·2	0·57	2·2	1·25	0·0259	0·1	0·003
9	8·7	0·60	2·2	1·32	0·0273	0·1	0·003
10	9·0	0·62	2·1	1·30	0·0282	0·5	0·014
11	9·0	0·62	2·1	1·30	0·0282	0·7	0·020
12	9·0	0·62	2·0	1·24	0·0282	0·9	0·025
13	9·0	0·62	1·9	1·18	0·0282	1·2	0·034
14	9·0	0·62	1·7	1·06	0·0282	1·5	0·042
15	9·0	0·62	1·4	0·93	0·0282	1·7	0·048
16	9·0	0·62	1·2	0·74	0·0282	1·8	0·051
Totals				14·24	Left hand ...		0·091
					Right hand ...		0·237

The reactions corresponding to the vertical loads have been obtained graphically in Figs. 1*b* and 2*a* as for a two-pin arch, thereby introducing an error of possibly 2½ per cent. for this class of loading. The horizontal thrust due to the vertical loads has been obtained by dividing the total bending moment, determined graphically in Figs. 1*a*, 1*b*, and 2*a*, by the rise of the centre line of the arch, 8ft. A more exact method of determining these values for a fixed end arch has already been described in these columns.* It is somewhat lengthy and the time required is scarcely justified in view of the nature of the assumptions made. The unequal lateral pressures on the two sides of the arch have very little effect, increasing the horizontal thrust by only 0·10 tons, and altering the vertical reactions by only 0·02 tons. The method for determining these values will be described in detail when the effect of passive resistance is taken into account. In Fig. 3 each of the partial loads on the arch has been increased by 0·24 tons, which is the weight of one division of the arch, and the vertical loads combined with the lateral pressures. In Fig. 2*b* the small crosses mark the intersections of the respective resultants of the superimposed load and weight of arch and the horizontal pressures, and through these crosses lines have been drawn parallel to the combined forces set out in Fig. 3. The line of thrust due to these forces can now be drawn, the vertical position being controlled by keeping the sum of the positive intercepts, above the centre line of the arch, equal to the sum of the negative intercepts below the centre line of the arch.

If the arch were subjected to this thrust the left-hand, or lightly loaded, half would be forced outwards and this tendency to move brings into play the passive resistance of the superimposed material. It has been assumed that a vertical load of $w\,h$ tons produces an active lateral pressure of $w\,h$ (1—sin 66 deg.)÷(1+sin 66 deg.) tons $= w\,h/22$ tons, and reversing the process it is argued that a force of $w\,h$ tons will resist a perpendicular force of 22 $w\,h$ tons. The available lateral passive resistance is therefore equal to 22 times the vertical load and 484 times the active lateral pressure. It is reasonable to assume that the passive resistance will be proportional to the movement resisted, and as under the loading considered the greatest lateral deflection would be at the crown, there will be little error in assuming the passive resistance as increasing from nothing at the left abutment to a maximum value at the crown, or, in other words, increasing proportionately to the vertical load and the active lateral pressure.

Experience shows that the best results are obtained by aiming at symmetry—that is, equally inclined reactions at each abutment—and this result is obtained, in the case under consideration, by assuming the passive resistance on the lightly loaded side of the arch to be forty times the active lateral pressure, which is only one-twelfth of the available resistance. The effect of this passive resistance is to produce an overturning moment on the arch, increasing the reaction on the right-hand side, and correspondingly decreasing the reaction on the left-hand side. The horizontal thrust at the crown is also increased. The lateral passive resistance on the left-hand side of the arch and the active lateral pressure on the right-hand side of the arch are shown in Figs. 2*c* and 4, and the overturning moments due to these forces are tabulated in Table II. The horizontal reactions at the springings are statically indeterminate, but the usual assumption is made that the excess of thrust at the crown on the left-hand side is equally resisted by both abutments:

TABLE II.—*Overturning Moments Due to Passive Resistance and Active Lateral Pressure per Foot Run of Arch*

Division No.	Passive resistance, tons.	Lever arm, ft.	Overturning moment, ft.-tons.	Division No.	Active lateral pressure, tons.	Lever arm, ft.	Overturning moment, ft.-tons.
1	0·23	1·35	0·31	16	0·051	1·35	0·069
2	0·44	3·1	1·36	15	0·048	3·1	0·148
3	0·58	4·7	2·72	14	0·042	4·7	0·197
4	0·63	6·05	3·81	13	0·034	6·05	0·206
5	0·59	7·1	4·19	12	0·025	7·1	0·178
6	0·58	7·9	4·58	11	0·020	7·9	0·158
7	0·46	8·5	3·91	10	0·014	8·5	0·120
8	0·10	8·8	0·88	9	0·003	8·8	0·024
Totals	3·61		21·76		0·237		1·10

Reaction at crown, $\frac{21\cdot76}{8}=2\cdot72^{T}$ — Reaction at springing $=0\cdot89^{T}$

Reaction at crown, $\frac{1\cdot10}{8}=0\cdot14^{T}$ — Reaction at springing $=0\cdot10^{T}$

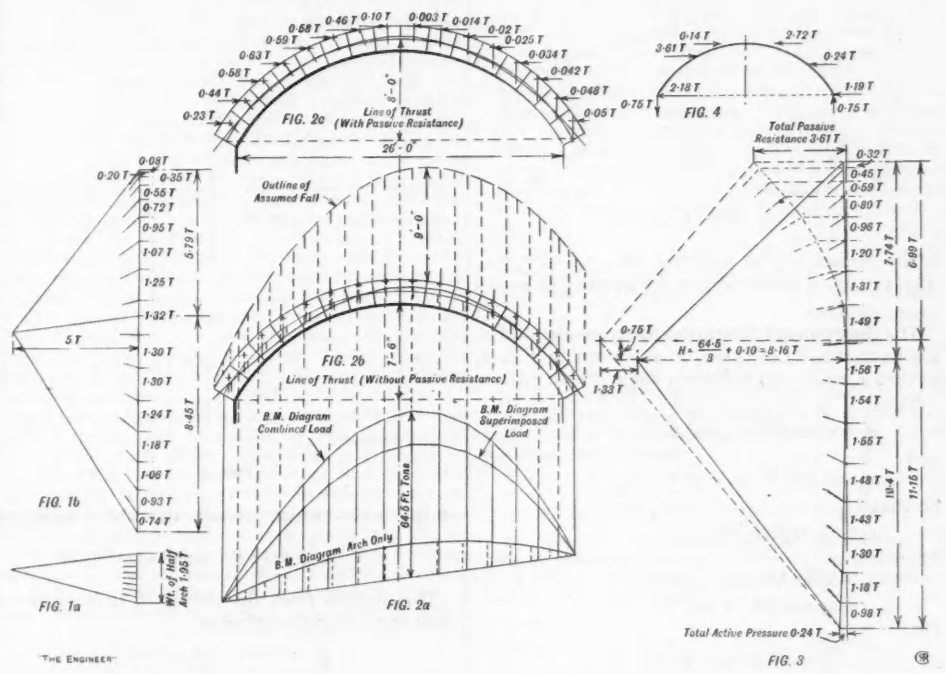
Net overturning moment, 20·66 ft.-tons

Increased and decreased vertical reaction, $\frac{20\cdot66}{27\cdot6}=0\cdot75^{T}$

The horizontal reactions due to the lateral forces are as follows:—

Left hand, $0\cdot89+\frac{1}{2}\ (2\cdot72-0\cdot14)=2\cdot18$ tons; right hand, $\frac{1}{2}\ (2\cdot72-0\cdot14)-0\cdot10=1\cdot19$ tons. The horizontal thrust at the crown, due to the lateral forces, is therefore: Working from left, $3\cdot61^{T}-2\cdot18^{T}=1\cdot43$ tons; working from right, $0\cdot24^{T}+1\cdot19^{T}=1\cdot43$ tons.

In Fig. 3 the dotted lines show the vertical forces combined with the assumed lateral passive resistance; the horizontal thrust at the crown has been increased by 1·43 tons, the value determined above, and the vertical reactions adjusted in accordance with the net overturning moment. From this modified vector polygon the revised line of thrust, or link polygon, illustrated in Fig. 2*c* has been obtained, and it will be noted that this revised line of thrust coincides far more closely with the centre line of the arch. Without taking passive resistance into account, the line of thrust is within 4½in. of the intrados of the arch, and the total pressure on the arch would have to be resisted by the inner three half-brick rings, producing a maximum compressive stress of about 16 tons per square foot on the brickwork. When passive resistance is taken into account the line of thrust does not depart more than 3½in. from the centre line, and there is a maximum bending moment pressure of 6·3 tons per square foot to be added to a direct or average pressure of 6·5 tons per square foot, resulting in a maximum compressive stress of 12·8 tons per square foot. These values have been calculated at the left haunch in Fig. 2*b* and on the right haunch in Fig. 2*c*. At the springings the thrust line would tend to be deflected inwards by the distribution of the reaction to the horizontal thrust over an area capable of resisting this thrust, and for this reason the stresses



* "Calculation of Stresses in Arches with Fixed Ends," THE ENGINEER, July 29th, 1932.

at the springings have not been calculated.

An essential condition to be fulfilled, in order that the passive resistance may be available, is that the space between the extrados of the arch and the surface of the excavation should be tightly and suitably packed, no matter how difficult this may be, especially in cases where part of the timbering has to be left in.

A Nomographic Solution of a Stress Problem

By D. E. THOMAS, M.A., B.Sc., F. Inst. P.

IT is possible in some cases to determine the stress in any direction in the surface of a metallic body by means of precision crystal lattice measurements made with X-rays. The error in such measurements will vary with the nature of the metal. But in the favourable cases the complete determination of the stress involves the determination of the magnitude and direction of the principal stresses.

The following is a convenient method of solving the equations involved.

The stress is first determined in three directions

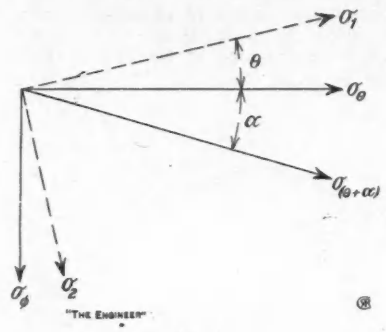


FIG. 1

in the surface of the material, say, σ_θ, $\sigma_{(\theta+\alpha)}$, σ_φ (Fig. 1), two of which, σ_θ and σ_φ, are at right angles to one another.

The directions of the principal stresses σ_1 and σ_2 are unknown. Let them be as shown in Fig. 1, so that σ_θ makes an unknown angle θ with σ_1.

Then

$$\sigma_\theta=\sigma_1.\cos^2\theta+\sigma_2.\sin^2\theta$$

and

$$\sigma_\varphi=\sigma_1.\sin^2\theta+\sigma_2.\cos^2\theta.$$

So that

$$\sigma_\theta+\sigma_\varphi=\sigma_1+\sigma_2=S \text{ (say)}.$$

Then

$$\sigma_\theta=\sigma_1.\cos^2\theta+(S-\sigma_1).\sin^2\theta$$
$$=\sigma_1.\cos 2\theta+S.\sin^2\theta.$$

Or

$$\frac{\sigma_\theta}{S}-\frac{\sigma_1}{S}.\cos 2\theta-\sin^2\theta=0.$$

Similarly

$$\frac{\sigma_{(\theta+\alpha)}}{S}-\frac{\sigma_1}{S}.\cos 2(\theta+\alpha)-\sin^2(\theta+\alpha)=0.$$

In these two equations σ_θ, $\sigma_{(\theta+\alpha)}$, S $(=\sigma_\theta+\sigma_\varphi)$

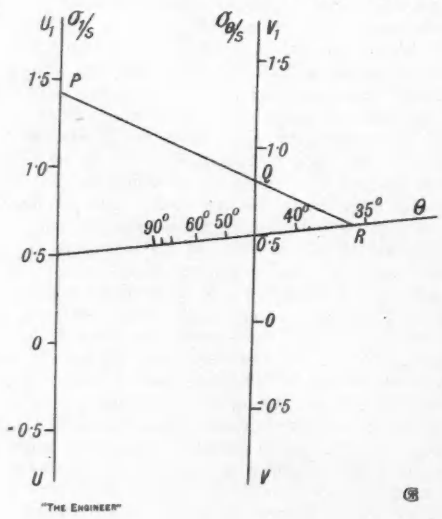


FIG. 2

and the angle α are known. The equations are to be solved for σ_1 and θ.

This type of equation can be put in the form of a nomogram. Two parallel straight lines U U_1, V V_1, are drawn as in Fig. 2. Similar uniformly graduated scales are laid out along them in the same sense. These are the scales of σ_1/S and σ_θ/S. Through the two 0·5 divisions a third straight line is drawn, O R, which is the axis of θ. Let the distance between these two 0·5 divisions be $2l$. Taking the mid-point between the two 0·5 divisions as origin (or zero) mark out on O R a scale of $l.\cot^2\theta$, graduating it in the appropriate values of θ. The 90 deg. graduation will be at 0 and the 45 deg. graduation at the 0·5 mark on V V_1, the σ_θ/S scale, and the 0 deg. graduation will be at infinity.

Then any straight line such as P Q R drawn to cut these three scales will pass through divisions

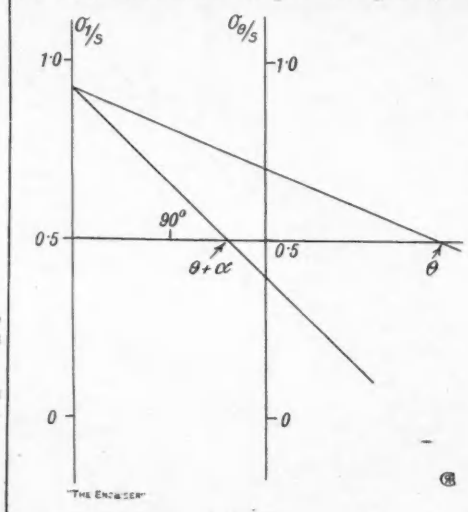


FIG. 3

of the scales which satisfy the above equation

$$\frac{\sigma_\theta}{S}-\frac{\sigma_1}{S}.\cos 2\theta-\sin^2\theta=0.$$

This follows from the theory of nomograms or from first principles as below.

$$P M=\frac{\sigma_1}{S}-\frac{1}{2} \quad Q N=\frac{\sigma_\theta}{S}-\frac{1}{2}.$$

Let

O R$=x$, then M R$=x+l$, N R$=x-l$.

Then

$$\frac{\frac{\sigma_1}{S}-\frac{1}{2}}{\frac{\sigma_\theta}{S}-\frac{1}{2}}=\frac{x+l}{x-l} \text{ or } \frac{2\,.\,\frac{\sigma_1}{S}-1}{2\,\frac{\sigma_\theta}{S}-1}=\frac{\frac{x}{l}+1}{\frac{x}{l}-1}$$

$$\therefore \frac{x}{l}=\frac{1-\frac{\sigma_1}{S}-\frac{\sigma_\theta}{S}}{\frac{\sigma_\theta}{S}-\frac{\sigma_1}{S}}=\frac{1-\frac{\sigma_1}{S}-\frac{\sigma_1}{S}\,.\,\cos 2\theta-\sin^2\theta}{\frac{\sigma_1}{S}\,.\,\cos 2\theta+\sin^2\theta-\frac{\sigma_1}{S}}.$$

$$=\frac{\cos^2\theta-\frac{\sigma_1}{S}(1+\cos 2\theta)}{\sin^2\theta-\frac{\sigma_1}{S}(1-\cos 2\theta)}=\frac{\cos^2\theta-\frac{\sigma_1}{S}\,.\,2\,.\,\cos^2\theta}{\sin^2\theta-\frac{\sigma_1}{S}\,.\,2\,.\,\sin^2\theta}$$

$$=\cot^2\theta.$$

To solve the simultaneous equations with the nomogram, two straight edges are pivoted on the σ_θ/S scale, one at the point corresponding to the measured value of σ_θ/S and the other at the point corresponding to $\sigma_{(\theta+\alpha)}/S$. They must be so adjusted (if possible) that they intersect one another on the σ_1/S scale and intersect the θ scale at angles α apart (Fig. 3). If this can be done the disposition of the directions θ, $(\theta+\alpha)$ and φ are as in Fig. 1.

If it is not possible to find such an arrangement of the straight edges, an arrangement must be sought in which they intersect one another on the σ_1/S scale and cut the θ scale at readings whose sum is α. This will correspond to the case where one of the principal stresses lies between σ_θ and $\sigma_{(\theta+\alpha)}$, as in Fig. 4.

When σ_1 and σ_2 are of different sign the nomo-

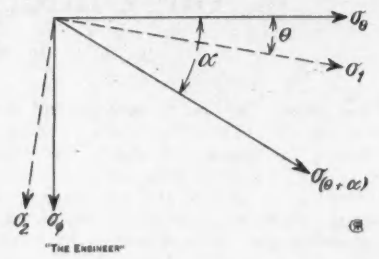


FIG. 4

gram can still be used in the same way, negative values of σ_1/S and σ_θ/S being marked on the scales. In this case the values of σ_1/S and σ_θ/S may be greater than 1.

If the direction of σ_θ happens to be so chosen that

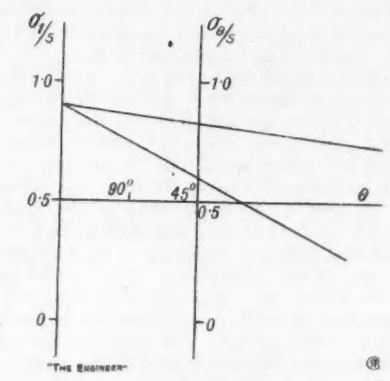


FIG. 5

θ is a small angle, say, less than 20 deg., one of the straight edges will intersect the scale of θ at a great distance from the zero (Fig. 5). If this is so, the straight edges can be turned about their pivots, as in Fig. 6, to give a pair of intersections near the

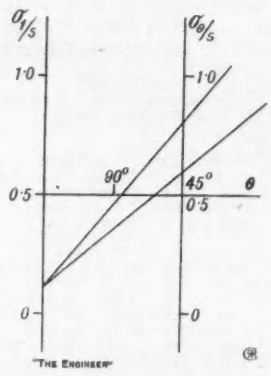


FIG. 6

90 deg. end of the scale. This will, of course, give σ_2/S, not σ_1/S. In this case, if no pair of intersections can be found whose difference on the θ scale equals α, a pair of intersections must be sought whose complements together equal α.

FANS AND ANCILLARY EQUIPMENT EXPORT GROUP.—The Fans and Ancillary Equipment Export Group has been formed, and duly recognised by the Board of Trade Export Council. The manufactures included in this Group are covered by the general classification of "all plant in connection with the movement of air by fans." They therefore include makers of fans, air heating, cooling, and conditioning plants, air ventilation plants, dust collection and air filtration installations, &c. The Executive Committee consists of seven members, of whom Mr. W. A. Davidson (Davidson and Co., Ltd.) is the chairman. The membership list, which is not yet complete, includes the names of twenty-five firms. All firms concerned in the manufactures covered by the classification given above are advised to join this Group without delay, in order to ensure their supplies of raw material, timber for packing, &c. The Group has already received allocations of steel, timber, &c., which it is in process of allotting to its member firms. Apart from bringing trading opportunities to the notice of its members, the Group is prepared to give its advice as to finance, provision of credit facilities, contract conditions, and similar matters. Overseas buyers will find the Group's services of use where they are in any doubt as to sources of supply. The secretary is Mr. Arthur G. Marshall, whose offices are at 2, Howard Street, Strand, London, W.C.2.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE PROCESS OF COMBUSTION IN SPARK IGNITION ENGINES

SIR,—Messrs. Fenning and Whiffin in their letter in THE ENGINEER of August 2nd claim that in their closed vessel explosion experiments the effect of fan turbulence on the pre-pressure combustion period was at least equal to that on the subsequent pressure rise combustion period, and that therefore it is unnecessary to differentiate between the mode of flame propagation during these two periods. The experiments of Messrs. Fenning and Whiffin are completely at variance with those made over a period of years by my colleagues in the Engineering Department of the University of Leeds, and also with those of Mr. Ricardo ("Proceedings," Inst. Aut. Engrs., March, 1930, page 647) on the delay period in petrol engines. It seems to me that it is a well-established experimental fact that the pre-pressure period and the delay period are uninfluenced by turbulence, and, indeed, Dr. D. R. Pye, in his book on the internal combustion engine (of which Mr. Fenning has knowledge), dwells at some lengths upon the practical significance of this. As Messrs. Fenning and Whiffin made their experiments some twenty years ago, it would appear to be well worth their while repeating them.

I do not think that serious objection should be taken to the terms "pre-pressure period" and "delay period." They have been in use for many years, and are very convenient as indicating the period after spark ignition during which there is no appreciable rise of pressure due to the spread of combustion.

W. T. DAVID.

August 15th.

AUTOMATIC TRAIN CONTROL

SIR,—From the interesting series of articles on automatic train control it appears that railway signal engineers favour the inductor method of conveying signals to the cab when control is effected on the intermittent system. The lack of any positive indication of danger is surely a serious drawback to the inductor systems which depend upon the passage of current supplied by local batteries on the locomotives or upon current picked up from the track, as in the combined track circuit and inductor system described in article No. IV. In these systems failure of the control current does not cause a positive danger warning to be given, and in this respect the mechanical ramp systems appear to be superior. The article states that unusual dimensions of rolling stock caused trouble in the matter of clearances and that ice packing against the ramps damaged the collector gear on the locomotives. The clearance trouble is one that should surely have been foreseen, and a robust plough on the locomotive would remove accumulations of ice before the collector shoe passed over the ramp. The rubbing action of the shoe effectively scrapes thin films of ice from the ramp and ensures good contact.

Safeguards can be, and probably are, incorporated in the inductor systems, but the descriptions do not deal with the effect of failure of current, or wiring, on the effectiveness of the systems described.

E. B. PARKER.

Little Sutton, Wirral, Cheshire,
August 17th.

POST-WAR EMPLOYMENT OF ACTIVE SERVICE MEN

SIR,—Your correspondent, Mr. Leonard Andrews, refers to the problem of post-war employment of active service men. Other minds are working on other problems concerning post-war conditions. But the more deeply we become involved in this problem, does it not become more clear that democracy has now got to take a new angle on the problem of the future of humanity?

We Britons—simple beings—do not wish to become any particular form of —ism; we are simply out to help our brothers and sisters to a higher plane of development. Why is it, then, that a temporary form of material force has held up our progress and threatened us with destruction? Is it not that we are not organised properly to co-ordinate modern forces? I suggest this is the simple answer, and a fact of momentous importance to humanity throughout the civilised world.

I suggest that we must reorganise from the Top. We have the brains, the experience and the moral fibre. Why don't we do it? In the past an "Industrial Parliament" has been suggested. It does not matter what it is called, but the time has arrived for a central organising force.

JOHN D. TROUP.

Purley, Surrey, August 19th.

Sixty Years Ago

CABLE GRAPPLING

IT is perhaps not fully realised that the history of the submarine cable was influenced almost as much by the development of means for recovering cables from the bottom of the sea as of means for laying them there. In 1850 the first cable, between Dover and Calais, was laid. It was 25 miles long, weighed 4 cwt. per mile, and lay, at the maximum, not more than 30 fathoms below the surface of the water. Its life was but a single day. It lasted just long enough to prove that submarine telegraphy was a physical possibility. In spite of its fate, the pioneers were not deterred, and during the succeeding eight years a number of cables varying in length from 200 to 500 miles were successfully laid, mostly in shallow water. In 1856 Cyrus Field came to England and formed a company to lay a cable connecting the Old and the New Worlds. The operation was begun on August 5th, 1857. On August 11th, after 335 miles had been laid, the cable broke in 2000 fathoms and the expedition failed. During the following year a second attempt was made. The cable was completed and for twenty-five days it worked successfully, carrying messages aggregating 4359 words. Then it failed and £415,000 worth of capital was lost. Investors felt their ardour damped, and it was not until 1864 that their interest in the Atlantic telegraph could be revived. On August 2nd, 1865, the second cable, while being laid, broke in 2000 fathoms. This cable weighed 35¾ cwt. per mile and had a breaking strength of 7·35 tons. It was recognised that if faith in the possibility of laying a Transatlantic cable was to be maintained it was essential to make an effort to recover the cable which had broken. The cable was duly caught, but as it was being raised a swivel gave way and cable, rope and grapnel went to the bottom. Three further attempts left the expedition with no more lifting tackle, and it had to return home. Nevertheless, sufficient had been done to show that with improved tackle a broken cable might be recovered from the bed of the Atlantic. Defeat was therefore not admitted. In 1866 the "Great Eastern" expedition succeeded in laying a new cable and then turned to the task of making a fresh attempt to recover the 1865 cable. This work was begun on August 13th, 1866. On September 2nd the cable was raised. It was found to be in perfect electrical condition. Accordingly it was spliced and completed to the American shore. This operation greatly encouraged investors, for it proved that they need not despair and need not lose all their money if a deep-sea cable broke while being laid or afterwards while in use. Improvements were made in grappling tackle, and so confident did investors become that during the ensuing fourteen years nearly 25 million pounds were invested in submarine telegraph cables. There still, however, remained some doubt as to the length of life of a cable, even if successfully laid. In our issue of August 20th, 1880, we recorded a fact which seemed to set fears under this head at rest. It had become necessary to raise from a depth of 2000 fathoms a portion of the cable laid in 1870 from Porthcurno, in Cornwall, to Lisbon, or alternatively to lose its service. Prophets abounded who said that after ten years' immersion it would be found to be rotten. When the cable was raised, however, it was found to be practically as perfect as when it was laid.

Priority in Munitions Production

THE following is a summary of the recommendations contained in the Tenth Report of the Select Committee on National Expenditure, to which reference is made in a leading article:—

(*a*) PRIORITY ORGANISATION

(i) That an extra-departmental body is needed with powers to compel consuming Departments, in cases where future difficulties of supply are foreseen, to modify their specifications or their quantitative requirements in advance of these difficulties.

(ii) That full inter-departmental co-ordination must be established if any system is to work smoothly.

(iii) That an independent Department comprising the priority organisation and the raw material controls should be established; and that this Department must have over-riding powers in the priority field.

(iv) That priority directions should be drawn up for specified periods (preferably not less than three months), based on detailed planning of the supplies and needs of the War Departments.

(v) That a system of priority grading should be established immediately.

(vi) That if priority certificates are issued these should not automatically be carried through to sub-contractors, but independent certificates should be granted to main contractors and sub-contractors.

(*b*) PROGRESSING ORGANISATION

(vii) That there should be far closer affiliation between inspection and progressing.

(viii) That departmental Area Progress Officers with local and general production knowledge should be appointed to work as part of the Area Organisation; and that progress reports should be submitted simultaneously to the Area Organisations and the Department.

(ix) That the whole Area Organisation should be expanded and unified on an inter-departmental basis; that it should be fully responsible for all area work concerned with production, capacity, labour and transport, and should co-ordinate and translate into action the decisions of the four Priority Committees.

(x) That progress branches should be established in Departments which should work in close connection with the Principal Priority Officer and his staff; and that progress inspectors with specialised knowledge should be appointed to work from departmental headquarters—the duties of these officers would be to inspect and accelerate the work on particular types of equipment irrespective of area.

(xi) That full inter-departmental control must be established throughout all stages from Cabinet direction to delivery to the user in order to eliminate competition and establish a national as opposed to a departmental outlook.

Since this Report was written a Memorandum on the recommendations in the Committee's Sixth Report has been received from the Ministry of Supply. The Committee is glad to record that in this Memorandum it is stated that the Area Boards have been reconstituted; that the Area Organisation of the Ministry of Supply has already been carefully reviewed; and that Area Progress Officers whose duties appear to be conceived on the lines recommended by the Committee above are now being appointed. The text of this Memorandum will appear as an appendix to the Committee's Eleventh Report.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

PRESSURE CREOSOTING OF TIMBER

No. 913. This specification covers the methods of pressure creosoting usually employed in this country and gives minimum absorption figures for effective treatment over a wide range of timbers.

CARBON STEEL CASTINGS

No. 592—1940. This revised Specification for Carbon Steel Castings covers steel castings for ships and for marine engine and general engineering purposes and supersedes B.S. Specifications Nos. 30—107, 592—1935 and 5028—1924. Three grades of castings are included, viz., those having a tensile breaking strength of 28 to 35 tons per square inch, 35 to 40 tons per square inch, and a non-test grade, i.e., castings which comply with the specification, excepting that sulphur and phosporus determinations and tensile and bend test are not required.

TUNGSTEN FILAMENT LAMPS

No. 161.—A new issue of the British Standard No. 161 for Tungsten Filament General Service Electric Lamps has been published. The actual modification to this edition is only a small one, viz., the raising of the efficiency of the 150-watt lamp and the change of cap of the 200-watt lamp. It was felt that a new edition should be issued, however, as there had been an addendum slip to the 1937 edition, which added a schedule for low-voltage coiled-coil filament lamps. There were also one or two printing errors in that edition, which have been corrected in the new issue.

INGOTS AND BRONZE CASTINGS FOR GENERAL ENGINEERING PURPOSES

Nos. 382 and 383.—The British Standards Institution has recently been engaged in a revision of a number of Specifications for Non-ferrous Metals, and amongst the revised Specifications which have recently been published are the following:—No. 382, 88/10/2 Bronze (Gun Metal) Ingots for General Engineering Purposes; No. 383, 88/10/2 Bronze (Gun Metal) Sand and Chilled Castings for General Engineering Purposes. The principal alterations that have been the subject of the revision are the manner in which the test piece is taken, and the inclusion of chilled castings within the scope of the Standard. The Specification for gun metal castings will now supersede the Specification of the aircraft series No. 2.B.2, which will shortly be withdrawn.

The Engineer

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*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

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*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses**, *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

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PRIORITY

THE priority organisation evolved during the course of the Great War originated in a "Priority Committee," an interdepartmental body which began its life without a written constitution and which for some time after its birth was not officially recognised. After many vicissitudes, much reorganisation and numerous changes of outlook, the Committee emerged into a "Joint Priorities Board," which took its instructions from a War Priorities Committee of the Cabinet and imposed its authority on the Admiralty, the War Office and the Ministry of Munitions. Machinery was devised to limit the competition between the Departments and to unify the form of the priority certificates with which each of them separately had, to the great confusion of manufacturers and contractors, flooded the country. Doubtlessly the Board as finally constituted would have been able to make a very great contribution towards the winning of the war. It never got a chance, however, to prove its full value, for just as it was perfecting its machinery and getting it into operation the war and the necessity for the existence of the Board came to an end on November 11th, 1918. One would have thought that with four and a-half years of practical war experience to guide us and with much close attention given in the later years of the intervening peace to the subject of munitions production in war time we would have begun the present war with clear-cut and agreed schemes covering the important subject of priority. In its details the problem of devising a satisfactory system of assessing the relative urgency of munitions orders, and of ensuring that the orders shall be executed in corresponding rotation, may have changed somewhat between 1918 and 1939. There is, however, no obvious ground for supposing that the general method of solving the problem should have required alteration in any radical respect. One would, in fact, have expected that last September would have seen a revival, at least in broad outline, of the priority organisation which was hammered out in the course of the last war and which in its final form seemed to contain the promise of a considerable measure of success. The Tenth Report of the Select Committee on National Expenditure, issued last week, reveals the fact that the priority organisation with which we began this war differed in many important and even fundamental respects from that with which we ended the war in 1918, that it has already been subjected to a number of changes and that if it is to achieve its full object in a satisfactory manner it must, in the opinion at least of the Select Committee, be changed still further. In brief it would seem that the history of the priority problem during the last war is likely to be repeated during this war in so far that before a satisfactory solution of it is reached the necessity for solving the problem is quite likely to have vanished.

Doubtlessly the problem of assessing and assigning priority in the manufacture of munitions in war time—especially in a war of the rapidly changing character possessed by that in which we are now engaged—is not a static problem. The primary need of the moment may be for aeroplanes and aeronautical equipment. To-morrow it may be for anti-tank guns and rifles and their ammunition, and the day after for all forms of tanks and mechanical transport. Doubtlessly, too, the solution of the problem cannot be based wholly on the requirements and conditions of the moment, but must anticipate to the utmost degree of human foresight the requirements and conditions of to-morrow and the next day. In these respects the Cabinet alone possesses the information needed to solve the problem. It knows, or should know, the weak spots in our current production of munitions and through its Intelligence Services and from its own deliberations on policy should be able to formulate some estimate of the quality and quantity of the munitions which will be required in the future. It and it alone can play the part of the signalman and take action to set the points which will lead the streams of production from the factories along the desired routes, shunting some which for a time had been in the van and releasing others which had been penned in sidings. If we liken the Cabinet to the signalman who pulls the levers, the levers themselves, the points and the signals may be likened to the various boards, councils and committees of our priority organisation and the trains and the goods which they carry to the works and the products of the munition manufacturers. The Select Committee on National Expenditure, if we may continue the analogy, can be described as playing the part of the patrolling inspector. Its Tenth Report is couched in terms which suggest that the priority organisation now in existence contains features which, translated into terms of railway operation, would reduce the working of any system to chaos. As now constituted our priority organisation is headed by the Production Council, a ministerial body, under which operate four sub-committees concerned with materials and production, transport, works and buildings and labour and man power. The first and second of these sub-committees are presided over by the Parliamentary Secretaries to the Ministries of Supply and Transport respectively and the third and fourth by the Parliamentary Secretary to the Ministry of Labour. The work of these four sub-committees is co-ordinated by a Central Priority Department in the Ministry of Supply, which acts as a form of clearing house and which alone possesses the authority to issue priority certificates. Apart from the constitution of the priority organisation, its function is effected in a manner essentially different from that followed by its forerunner in the last war. Priority certificates were then issued with respect to the finished product. As originally established the priority organisation of the present war was designed on a raw material basis, namely, to secure "the proportionate allocation to each service, in accordance with the best national interest, of such raw materials as are in short supply." A partial approach to the 1918 basis has recently been made by the assignment of priority categories, 1*a* and 1*b*, to two short lists, not of particular products, but of certain specified classes of armament. The Select Committee, as will be gathered from the summary of its recommendations, printed elsewhere in this issue, does not regard this organisation with complete satisfaction. Its main recommendation, it will be noted, is that an independent department should be set up comprising the priority organisation and the raw material controls with over-riding powers in the priority field. It also recommends that a system of priority grading of actual products similar to that evolved towards the end of the last war should be gradually grafted on to the existing priority arrangements. The Select Committee has found less to criticise in the existing organisation as it makes itself felt in the factory than in its departmental status and in its executive relationships. It makes certain recommendations concerning modifications in the existing system of supervising the progress of work through the factories and of ensuring an even flow of output. In several instances its recommendations under this head have been anticipated by action taken by the Ministry of Supply.

Whatever form of priority organisation may be adopted, the hard kernel of the problem of supplying the nation's forces with the requisite supplies in the required quantities and at the right moment remains with industry and in especial with the engineering industry. A sound priority system cannot be otherwise than of immense advantage to the nation's present effort. A less than sound system may well prove a hindrance rather than a help. That our existing system is not wholly sound is suggested by the evidence of one witness called before the Committee, who testified that "if he followed literally every order he received about the urgency of various articles he would have his shops full of half-finished stuff owing to continued switching from one job to another." Again the Report records that a certain firm received a letter from a Department giving complete priority to some weapons which it was making. Two days later it received a letter from another Department telling it to take no notice of instructions purporting to give priority to particular work and stating that all armament work was of equal importance. In spite of these illuminating sidelights on the operation of our existing priority organisation, we do not despair of the situation. As a nation we have an undoubted genius for bringing—even if late in the day—order out of apparent chaos. The production of the vast volume of munitions which the country needs at the present moment is in essence an engineering problem. It will best be solved by leaving its solution to engineers with just as much guidance and as little interference from departmental authorities as will serve to secure the desired orientation of effort. Knowing the engineers—masters and men—of Great Britain as we do, we feel not a shadow of doubt that in so far as victory rests with them, victory will be achieved whatever difficulties they have to face, whether these difficulties arise from the bombs of the enemy or a bombardment of priority forms, certificates and instructions from Whitehall.

Serendipity

THE world has to thank Dr. W. B. Cannon, of the Harvard Medical School, for reviving a word which, despite its august parentage, has rarely attained the dignity of lexicographical recognition. It was Horace Walpole who coined "Serendipity" and dubbed it "very expressive," as indeed it is. In a letter of January 28th, 1754, to Horace Mann, he wrote: "I once read a silly fairy tale called The Three Princes of Serendip: as their Highnesses travelled, they were always making discoveries, by accidents and sagacity, of things which they were not in quest of: for instance, one of them discovered that a mule

blind of the right eye had travelled the same road lately, because the grass was eaten only on the left side, where it was worse than on the right—now do you understand Serendipity ? " Serendip, in passing, was once a name for Ceylon. Dr. Cannon used the word in an address on " The Rôle of Chance in Discovery," and pointed out that whilst serendipitous discoveries were well known in his own field—physiology—they were always made by trained discoverers. Probably that is nearly always the case. Even in the classical example of Saul who went out to look for his father's asses and found a kingdom, it must be remembered that the discovery was not in reality fortuitous and that the prophet Samuel had his hand in it.

In the realm of engineering and general technology, there are numerous examples of Serendipity ; but sometimes they owe more to the love of the picturesque than to the bare facts. To this day the legend of Watt and the kettle is an article of faith to those who see the dramatic and emotional side of engineering, and the traditional story of Goodyear's discovery of vulcanising is more nearly apocryphal than genuine. On the other hand, there are dozens of unquestionable instances on record, and hundreds, probably thousands, that have passed unnoticed, for the development of inventions frequently results from the observation of fortuitous events. Take, for example, the improvement of the screw propeller by Francis Pettit Smith. His original propeller was a real screw or helix of two complete turns. By a fortunate accident during trials in the Paddington Canal a part of the helix was knocked off and the speed of the boat immediately increased. Smith jumped at this serendipitous discovery, made a new propeller of improved design, and established his name and fame for evermore. Of a somewhat different order was the discovery of argon. Rayleigh set about weighing nitrogen, expecting to find it a relatively easy task ; and so it was at first, and so would have remained had not Rayleigh wanted to make doubly sure. He first weighed nitrogen derived from the air and got consistent results. Then he prepared nitrogen from ammonia quite expecting it to have the same weight ; but it had not ; it was a little lighter. And however he made pure nitrogen it was always a little lighter than atmospheric nitrogen. At length, after years of work, he reached the no longer avoidable conclusion that the nitrogen of the air was always accompanied by a heavier gas ; that gas was at length isolated and called argon. But chemistry is full of similar examples of Serendipity. Perkin, " washing bottles in the laboratory of Hoffman in London, mixed at random the contents of two flasks and discovered a method of synthetising mauve—the first of a long series of coal-tar dyes." Priestley, putting a burning candle in a bottle of gas found oxygen. " More," he said, " is owing to what we call chance than to any proper design or preconceived theory," which shows that he was at heart the complete serendipitist. Again, Serendipity played no small part in the invention of the thermionic valve. Fleming noticed that if the carbon filament of an incandescent lamp were overrun the globe was blackened, but " in a certain number of cases there was a white or clear line of no deposit on the glass which was in the plane of the loop." " This showed me," he wrote, " that the carbon atoms must have been shot off in straight lines from some one point on one side of the loop, and that the other side of the loop, so to speak, cast a ' shadow,' or, as I called it, a ' molecular shadow,' thus causing a clear line of no deposit on one side of the bulb." It was this observation which prepared Fleming's mind for the research which he made later into the " Edison effect," and which lead directly to the invention of the rectifying valve and the development of " wireless." Yet one more instance, just to show how the serendipitously minded come to fame when those who are not, or who are " docile minded," as Lodge once called it, miss their chance. The Rev. Frederick Smith, an amateur physicist of some distinction, had observed with irritation that photographic plates were spoiled when in the neigbourhood of vacuum tubes. Instead of following up the observation he had the plates removed from the source of infection and so left to Röntgen the honour of discovering X-rays. Even so the discovery was serendipitous for it was by chance, not by intention, that Röntgen had a fluorescent screen beside him on the table at which he was working with vacuum tubes.

These few examples of Serendipity are taken from books picked up more or less at random. If we went on browsing amongst the shelves many more would come to light. Indeed, we should find ourselves forced to agree with Priestley that many discoveries are due to pure chance—like some of the best effects of the great water colourists. But we fear Serendipity is doomed or will live only in historical works. Organised research is killing it. The stream of knowledge is being overfished. There are no sizable trout left in it. A problem has only to pop up its head for an instant when a thousand anglers are round it resolved upon its fate. The basket is greater than ever, but it is composed of small fry with a very, very occasional twenty-pounder—whitebait to salmon. Nothing is given a chance to pass unobserved or undiscovered ; the net of unlimited research traps them all and the happy hunting and exultation of the serendipitist is becoming a thing of the past. What a dull place the completely organised world will be !

Obituary

H. C. BYWATER

With profound regret we have to record that Mr. Hector Charles Bywater, who for many years past has been a regular contributor to The Engineer on naval subjects, died in his sleep at Richmond, Surrey, on August 17th, in his fifty-sixth year.

Between 1898 and 1914 he lived abroad, at first in Canada and the United States, and later in Germany, where he became engaged in journalism. In the years immediately preceding the Great War he gave frequent warning of the approach of " Der Tag " in the columns of the *Pall Mall Gazette*, *Daily Graphic*, *Naval and Military Record* and *Navy League Journal* (now known as *The Navy*). When war began he was in this country, and for some time assisted Sir Archibald Hurd, then Naval Correspondent of the *Daily Telegraph*, with whom he collaborated in a book entitled " The Fleets at War," published in 1915. He also placed his knowledge of German naval affairs at the disposal of the authorities, and was subsequently employed in confidential intelligence work until the end of the war.

From 1921 to 1930 Bywater was Naval Correspondent in London of the *Baltimore Sun*. From 1923 he was also Naval Correspondent of the *Daily News* and of the *Observer*, posts which he relinquished in 1928 to become Naval and Shipping Correspondent of the *Daily Telegraph*. He resigned from the staff of that paper last year owing to the breakdown in his health ; but a few months ago his friends were relieved to learn that he was much better, and had accepted a fresh appointment as Naval and Shipping Correspondent of the *News Chronicle*, with which paper he had previously been associated when it was the *Daily News*.

He was the author of several books, of which the most important was " Sea Power in the Pacific," first published in 1921 and since re-issued. He also wrote " Navies and Nations," 1927 ; " Their Secret Purposes," 1932 ; " A Searchlight on the Navy," 1933 ; and " Cruisers in Battle," 1939 ; " The Great Pacific War " (1935) was written in collaboration with Francis McMurtrie, and " Strange Intelligence " (1931) with H. E. Ferraby. In 1926 Bywater won the gold medal awarded as first prize in the International Essay Competition of the United States Naval Institute, of which he was thereupon made a life member. In this he repeated the success achieved many years earlier by the late Sir William Laird Clowes, another former contributor to The Engineer. Bywater was married twice and leaves a son (the Rev. Robin Bywater) and daughter by his first wife. His loss will be felt deeply by his many friends in Fleet Street and elsewhere. He had an unequalled knowledge of the ships of war of all nations and his study of naval history and of international politics as conditioned by sea power was extensive. To all this he added a facility in literary expression which put him in the front of the writers on naval subjects of his time. Although most of his articles in our columns were unsigned, the clearness of his style and the evidence of complete knowledge of his subject gave them a character which made them recognisable to all who knew his work. He was well known in the British Navy and by scores of officers ashore and afloat, had been to sea many times with the fleets on naval manœuvres and on other occasions had sailed in all types of vessels.

It is difficult to say what a loss his death means to ourselves and other newspapers. As much at home with leading articles as with descriptions of ships, tactics and manœuvres, and blessed with a literary style of the highest lucidity, he was an invaluable Press man, and it will be exceedingly difficult to find his equal. On the personal side we shall say no more than that we have lost a friend and associate of many years standing whom we valued not for his work alone.

WALTER P. CHRYSLER

By the death of Mr. Walter P. Chrysler, president of the Chrysler Corporation of America, which took place on Monday, August 19th, at his home, Great Neck, New York State, America has lost a leading designer and manufacturer of motor cars, whose name is world renowned. Walter Percy Chrysler was born at Wamego in Kansas in 1875, and was the son of a Dutch railway engine driver. He was apprenticed in the shops of the Union Pacific Railway at Kansas, and rose rapidly, becoming successively machinist, roundhouse foreman, and a master mechanic. At the age of thirty-three he was appointed superintendent of motive power, and in 1910 became assistant manager of the Pittsburg works of the American Locomotive Company. A year later he was made manager of the company. In 1912 he left locomotive building to join the Buick Motor Company at Detroit, remaining until 1920 when the works were taken over by the General Motors Corporation. In that year he became vice-president of Willys-Overland, and two years later he started the company which bears his own name. He became successively president of the Chrysler Corporation and chairman of the board of directors, and later on merged the Dodge Company with his own organisation. He moved to New York, which he made his headquarters in the famous 68-storey Chrysler building, which was constructed at a cost of nearly £3,000,000, on a site near the Grand Central Station on Forty-second Street.

FREDERICK BEST

The steel industry of Sheffield has lost an outstanding figure by the recent death, at the age of seventy-four, at his home at Ross-on-Wye, of Mr. Frederick Best, a director and the secretary of Thos. Firth and Sons, Ltd., of Sheffield, prior to that firm's amalgamation with John Brown and Co., Ltd. Mr. Best was also the nominee director of Thos. Firth and Sons, Ltd., on the boards of the Firth-Brearley Stainless Steel Syndicate, High Speed Alloys, Ltd. (of Widnes), and Firth-Derihon Stampings, Ltd. He joined the firm as head of the steel foundry department, and during his career he travelled widely on behalf of the firm in the United States of America and also in Canada and Russia. Mr. Best was a valued member for many years of the Sheffield Chamber of Commerce, the Federation of British Industries, and the Society of British Aircraft Constructors. During the last war he acted as the Secretary of the Aircraft Steelmakers' Committee, and was appointed by the Ministry of Munitions a member of the Advisory Committee which was charged with the duty of arranging for the supply of high-speed steel to the Allies for the manufacture of munitions. In 1922 Mr. Best was appointed the commercial manager of Bolckow, Vaughan and Co., Ltd., of Middlesbrough. His death will be deeply regretted by a wide circle of business friends.

Stainless Steel Coaches.—The first American stainless steel railway carriages to be built for export are now under construction for the Portuguese National Railway, which has placed an order for twenty-eight of these units with the E. G. Budd Company. Although the cars differ somewhat from American pattern stock in strength, weight, and gauge, the general design is similar to the usual Budd type of construction, in which sides, roofs, and floor perform all load-carrying functions.

Developments in Air-Break Circuit Breakers

No. I

FROM the earliest days of D.C. practice air-break circuit breakers have been used with success on low-voltage circuits in the electrical power industry. For alternating currents at higher voltages the oil circuit breaker was introduced, but in view of the good performance of air-break switchgear for lower pressures the use of oil is considered in certain quarters to be unnecessary. Existing methods of testing of oil and air-break switchgear alike have led Mr. A. R. Blandford, chief engineer and manager of the English Electric Company's switchgear department, to give attention to improvement in interrupturing capacity to ensure that none of the desirable features of the oil circuit breaker have been sacrificed in the development of air-break gear which eliminates fire risk.

Needless to say, the introduction of an air circuit breaker possessing all the desirable qualities of oil-break gear is an important advance in the march of progress. Although 25 MVA is a small amount of power from the rupturing capacity point of view, the value, which is a standard at 400 volts, produces approximately 36,000 R.M.S. amperes breaking current and demands a peak-making current of 92,000 amperes. In handling

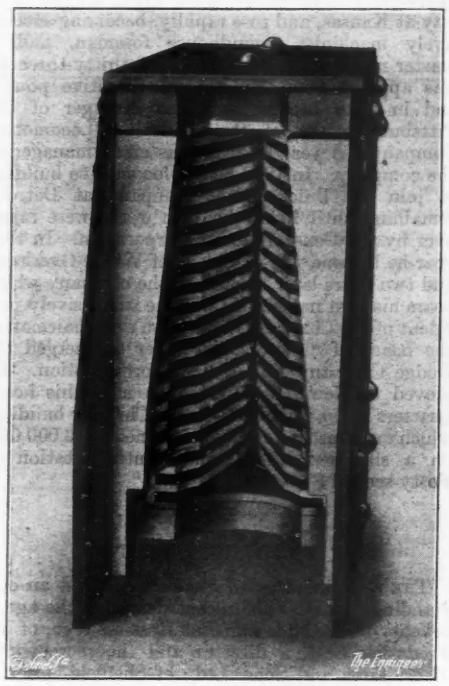


FIG. 1—BOTTOM VIEW OF ARCING CHAMBER

currents of this magnitude, which, by comparison, are five times greater than those met with at 1,500,000 kVA rupturing capacity at 132 kV, it was found on short-circuit test that contact deterioration in oil was so severe when carrying out a B.S.S. duty cycle and with refractory metals used for the arcing contacts, that attention should be given to some other form of arc rupturing device for capacities above 15 MVA at 400 volts.

Excessive burning of contacts in oil at currents in the neighbourhood of those under consideration is attributable to the constriction of the arc by the oil which localises the arc and forms undesirable craters. Obviously the cure demanded a method permitting free movement of the arc and at the same time provided the necessary amount of constriction to prevent it getting out of control.

Although the air circuit breaker is not a new or novel device, tests indicated that the older types of air circuit breakers needed considerable development to make them suitable for modern operating and test conditions. Improvements were required to make the equipment suitable for (1) complete metal enclosure, (2) making and breaking the heavy short circuits on the contacts, (3) provision for standing up to the heavy magnetic forces, and (4) mounting in the same space as that required for oil circuit breakers.

Attention also had to be paid to simplicity of design, breaking capacity, high insulation level, and high operating speed. In the English Electric circuit breakers these objectives are claimed to have been achieved. Considering first the 400-volt design of the arcing chamber, the usual method of controlling an arc in air is by means of magnetic blow outs, which generally tend to intensify the noise of the breaker during operation and frequently introduce complications with regard to thermal capacity and the satisfactory insulation of the blow-out winding from the

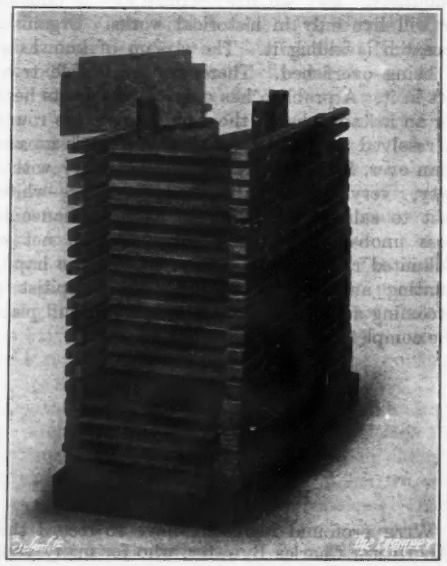


FIG. 2—TOP VIEW OF ARCING CHAMBER

arc and earthed magnetic paths from the arc. For the voltage mentioned there are in the present case a number of insulating plates of non-gas-forming material with V-shaped slots, as shown in Fig. 1, separated at intervals of about $\frac{3}{16}$ in. and at right angles to the arc. The arrangement allows free ventilating space at the top for the escape of gases, thus keeping down back pressure, which would prevent the gas from rising freely.

The slots are much narrower at the upper end

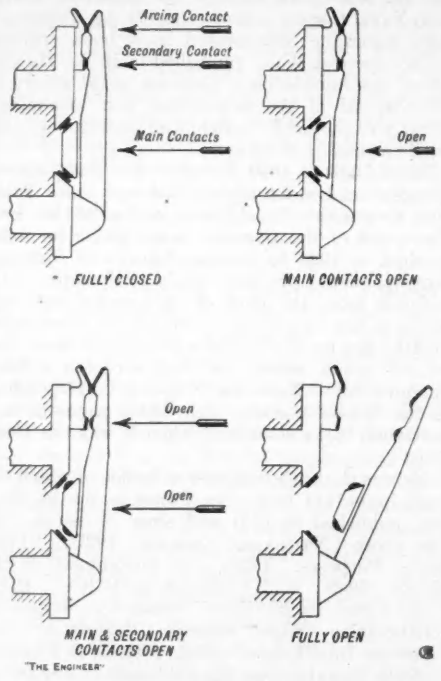


FIG. 3—CONTACT OPENING SEQUENCE OF A 400-VOLT AIR-BREAK CIRCUIT BREAKER

than at the lower end, where space is needed for the movement of the arc tips and the contact arm. To be efficient an interrupting chamber requires a correct balance of arc constriction and magnetic control. The shape of the insulating plates and spacing ensure sufficient constriction and reduce the arc section sufficiently to make the magnetic operation effective. Magnetic control is obtained by self-induction, by mounting a series of iron plates equal in number and having the same spacing as the insulating plates. Mounted in the same plane and situated at the top of the arcing chamber as shown in Fig. 2, they offer no additional restriction to the arc or the arc gases. The iron plates also have the effect of more efficiently cooling the gases which have previously been acted upon by the insulating plates. Hence there is very little visible display of the gas at the top of an arc-control device constructed in this way. In the arcing chamber illustrated in Fig. 2 a number of the magnetic plates have been removed to expose the insulated plates, and the shape of the magnetic plates can be seen from the plate which has been placed above the chute.

A chamber built in this way is almost equally suitable for D.C. interruption, as in this case the field is strongest when the current is high as at the beginning of the interruption. This allows the effect produced by the magnetic control of the field to be initially high to counter the ionising action produced by the heavy current. Likewise as the current decreases both ionisation and magnetic control de-ionisation forces subside. During A.C. operation, the arc is interrupted at an early current zero, but the arc drop is not high until the end of the arcing half-cycle, owing to the current sine wave and its effect on the field. Normally there is only one half-cycle of arcing, except in cases where the contacts part just prior to current zero, when the time would be one half-cycle longer.

Equipped with these interrupters, breakers have been tested with satisfactory interruption up to maximum short-circuit capacity in earthed enclosures having the top surface only 1in. above the

FIG. 4—CIRCUIT BREAKER IN OPEN POSITION

arc chamber. The chamber also considerably reduces noise. Pressure drop in the chamber is approximately only 50 volts R.M.S. per inch of arc length when clearing on a 400-volt, three-phase circuit.

Air-break circuit breakers of this class have to deal with large currents, and one of the objects in the design of such a breaker is to ensure that the normal current-carrying section of the apparatus is unaffected by short-circuit interruption. In the English Electric Company's breaker this has been achieved by resorting to a three-stage contact arrangement. In Fig. 3 is shown the contact opening sequence. The first stage, consisting of main contacts, serves for carrying the load alone; the second is an auxiliary arcing stage which serves to protect the main contacts from deterioration during interruption, and at the same time reduces the time interval during which the main arcing contacts have to deal with the whole of the current, either during "a making or a breaking" movement. The third stage consists of the final arcing contacts.

To provide for the correct mechanical sequence of contact operation, a rigid pivoted contact arm, carrying a floating main contact bridging member, and rigidly fixed secondary contacts, comprise the moving contact system. A movable platform member is attached to the panel and is connected to the upper main fixed contact of the first stage on the panel. As the breaker opens, the former moves, conjointly with the contact-carrying arm, in such a way that the secondary contacts of the second stage and the arcing contacts of the third stage do not slide on each other or separate. For the sliding platform member the necessary free-

dom of movement is provided by a slot in the side plates which support it. After a sufficient degree of motion has occurred to enable the main contacts to separate, a pin, which is a part of the platform member, reaches the end of the slot in the side plates, whereupon the secondary contacts part. With continued further action, the platform member pivots about this pin, and the secondary contacts on the secondary side move backwards, while the arcing contacts remain closed until the stop at the upper portion of the platform member reaches its limit position and at this point the arcing contacts separate.

It has been possible by means of this construction to enclose the springs and shunts completely, and to provide a simple and unusually neat design, which obviates the undesirable features of the earlier types of air-break circuit breaker, in which the moving contact and the arcing contact are usually flexible and are therefore affected by the magnetic blow-off forces which arise with the passage of short-circuit currents.

The overall dimensions of the new breaker for 1600 amperes are no greater than those of the earlier forms of simple breaker which incorporated a laminated brush construction and was rated at 800 amperes for the same temperature rise. For the lower and fixed main contact block of the first stage copper is employed, and is provided with a flat copper bridging member which breaks contact when the circuit breaker is opened. To increase the current capacity of these contacts, silver plates are brazed on to the contact faces of both the moving and stationary member, and to ensure long life and freedom from maintenance, these plates are of adequate thickness. The bridging-contact member is held in the closed position in contact with the fixed members by powerful spring pressure

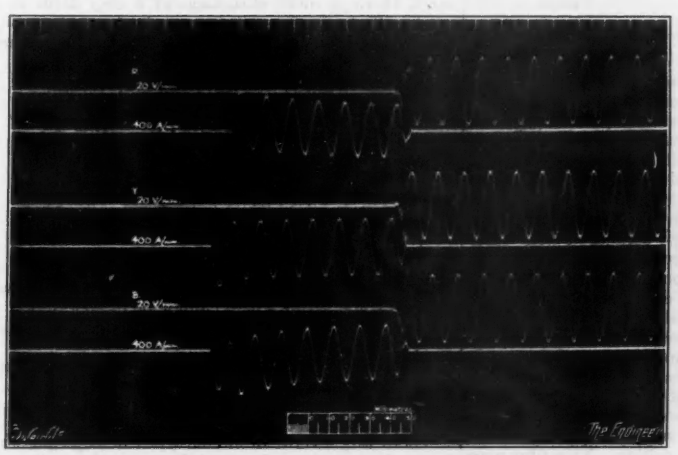


FIG. 6—OSCILLOGRAM OF 10 PER CENT. 3-PHASE "BREAK" SHOT. SYMMETRICAL AMPERES 3680, 400 VOLTS, 2·5 MVA

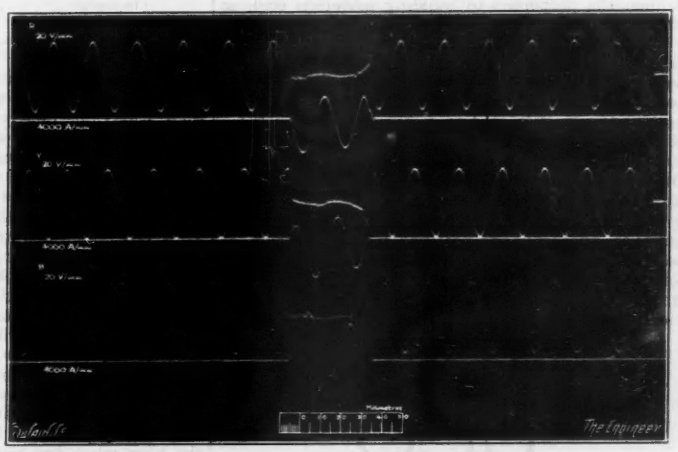


FIG. 7—OSCILLOGRAM OF 100 PER CENT. 3-PHASE "MAKE BREAK" SHOT. SYMMETRICAL AMPERES 37,000, 400 VOLTS, 25·6 MVA

sufficient to ensure a low contact voltage drop with normal load current.

As shown in Figs. 4 and 5, the shape of the surface of the silver plates of the bridging member is

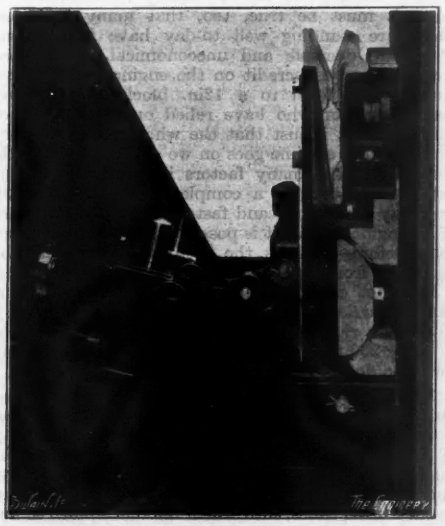


FIG. 5—CIRCUIT BREAKER IN CLOSED POSITION

segmental in order to ensure the correct alignment between them and the main contacts, which are fixed at an angle of 45 deg., so that the contact lines will come to lie on the surface of a cylinder. Correct alignment of the contacts is therefore achieved, since the cylinder will align itself with the two planes formed by the stationary stub

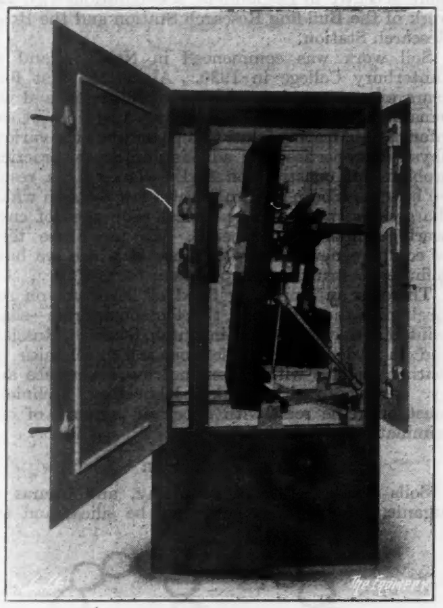


FIG. 8—SIDE VIEW OF BREAKER IN THE ISOLATING POSITION

contacts if the bridging member is free to slide to the correct position. For the secondary contacts the material must be suitable for resisting a certain amount of arcing, and as the chief object of these contacts is to protect the main contacts from burning the contact drop of this material must be kept as low as possible. The material for the arcing contacts must resist damage from the arc and as the question of contact drop is not so important for these contacts the material used differs from that employed for the secondary arcing contacts. Metal which is far superior to carbon is used in both cases, for the contact volume can be made very much smaller and have better thermal capacity besides better conductivity. Moreover, there is less risk of breakage.

A feature of the design considered to be of considerable importance is the use of adequate shunts for connection between the secondary and main contacts for the transfer of the current without burning the main contacts. Connected to the moving platform member these shunts are so arranged that the heavy short-circuit current will tend to increase the contact pressure of the secondary contacts. The current path to the arcing contacts is constructed so that the magnetic field directs the arc upwards into the arcing chamber on its formation. Consequently, for maintaining an adequate contact pressure against the effect of the very high short-circuit currents the contact pressure of the arcing contacts depends upon the pressure exerted by the springs.

To give additional protection from damage to the main contacts overlapping insulating baffle plates are inserted between the secondary contacts and main contacts so that any gases which may tend to move downwards are deflected, thus preventing the arc from damaging the main contacts when interrupting heavy currents. To minimise the energy which must be dissipated and interrupted, a high mechanical speed of breaking is necessary, and this is achieved by making the moving contact arm and its associated members as light as possible, and by using powerful springs to produce initial acceleration. With the higher ranges of short-circuit currents complete operation from the time of application of the tripping effect until the extinction of the arc is achieved in one half-cycle. Normal operation at very low values of the short-circuit current does not, as a rule, exceed two half-cycles. To absorb the shock arising from the high speed of the contact arm on opening, air-dashpot buffers are employed.

Single-phase and three-phase short-circuit tests have been carried out at 400 and 600 volts, 50 cycles, the test range in current values extending from a few amperes up to 40,000 amperes symmetrical R.M.S. breaking. Crest values of over 100,000 have been dealt with on "making" shots. The oscillograms, Figs. 6 and 7, show how rapidly and smoothly the arc voltage increases, and the effective arc extinguishing action is obtained. The former oscillogram relates to a 10 per cent. three-phase "break" shot, symmetrical amperes 3680, 400 volts, 2·5 MVA, and the latter to a 100 per cent. three-phase "make break" shot, symmetrical amperes 37,000, 400 volts, 25·6 MVA. Arcing time is limited to approximately one half-cycle, whether operating a 10, 30, 60, or 100 per cent. cycle duty. The fast breaker action provides an overall operating time varying from 3 cycles at low short circuit values of current to 1½ cycles at very heavy currents.

In Fig. 8 is shown a side view of a 400-volt, electrically operated circuit breaker with the breaker in the isolating position. The circuit breaker is mounted on a panel hinged at the bottom and arranged to allow of forward movement, while a lever arrangement operated by a detachable handle serves to close the circuit

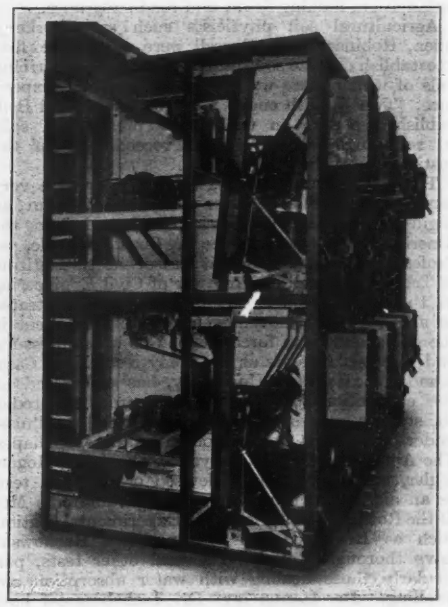


FIG. 9—DECK METHOD OF ASSEMBLY

breaker if the breaker is hand operated. Back-of-panel contacts, with the panel in the normal vertical position, engage corresponding stationary

contacts to which the bus-bars and cable circuits are connected.

Movement of the isolating lever allows the panel about a 10 deg. forward movement, as shown in Fig. 8, which is sufficient for isolation. But for inspection and maintenance the panel can be dropped further forward through the front door opening to almost a horizontal position. Complete mechanical interlocks give the usual protection against access to live parts and prevent making or breaking the circuit on the isolating contacts. Equipments can be built up side by side to form switchboards, and where space is restricted a double-deck arrangement (Fig. 9) can be employed to allow the circuit breakers to be mounted one above the other. In the illustration the side sheet is removed to show the interior.

By the utilisation of this new form of arc-interrupting device in conjunction with a fundamentally improved air-break circuit breaker, it has been possible to manufacture breakers of this kind comparatively small in size which will repeatedly rupture 40,000 R.M.S. symmetrical amperes or equivalent values of D.C. The noise that is usually experienced with air-break circuit breakers when operating on short circuit has been considerably reduced, while the extent of ionised gas or flame has been sufficiently diminished to give these breakers a space factor comparable with oil circuit breakers.

(To be continued)

Soil Mechanics in Foundation Engineering*

By R. L. JAMES, B.Sc., A.M. Inst. C.E., A.M.I. Struct. E.

FOR many years engineers and chemists have studied the properties of building materials such as steel, concrete, and timber, until to-day it is possible to design huge chords of a Sydney Harbour Bridge in high-tensile steel alloys and to compute the effects on it of the primary stresses of loading, impact, and wind, and the secondary stresses imposed by temperature and joint deformation. Our knowledge of concrete water-cement ratios, grading, and workability also permits the safe design of a Boulder Dam, or a fifteen storey reinforced concrete building subjected to earthquake stresses.

It is only during comparatively recent years, however, that soil has received much attention as an engineering material. This despite the fact that soil problems are important in earth-fill dams, stopbanks, retaining walls, building and bridge foundations, irrigation and drainage schemes, tunnel

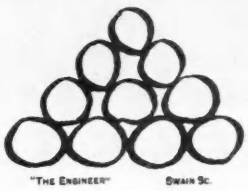


FIG. 1

linings, railway cuttings and embankments, harbour reclamation, landing fields, and road subgrades.

Agricultural soil physicists such as Atterberg, Oden, Robinson, and Russell were among the first to establish definite soil tests as a means to describing soils of which there was some practical field experience. Two English engineers, Crosthwaite and Bell, published papers on the lateral pressure of soils on retaining walls in the "Proceedings" of the Institution of Civil Engineers.

Then came Dr. Terzaghi, who has exerted a very considerable influence over the subject from an engineering point of view. As Lecturer in the American Roberts College in Constantinople, as Professor of Soil Mechanics at Massachusetts Institute of Technology, and as Professor of Civil Engineering at the Hoch Schule, Vienna, he has concentrated on showing what movements of water will occur in the soil under given forces of load or water pressure, and what settlements or slips may result. Dr. Casagrande, of Harvard University, has elaborated on the calculations of Boussinesq in order to predict the stresses imposed at different points of a soil mass under large area foundations of different shapes. The Americans Gilboy, Bouyoucos, Krynine, Hogentogler, and Proctor have devised or modified tests as an aid to describing the soils encountered. Men at the Rothamsted Agricultural Experimental Station, such as Russell, Coutts, Keene, and Rachowski, have thoroughly explored several other tests, particularly those dealing with water absorption and swelling. Dr. Hanna and Dr. Tschebotareef have done valuable work in Cairo comparing laboratory predictions of settlement with levels taken periodically on actual buildings. The American Bureau of Roads has divided soils into eight classes for highway work, and this classification has been copied with little change by the Main Roads Board of Victoria, Australia. Soil laboratories have been organised more recently in England in collaboration with the work of the Building Research Station and the Road Research Station.

Soil work was commenced in New Zealand at Canterbury College in 1930. About the first four years were devoted to a study of the tests, and the remainder of the time to building up tables of soil information, tracing relationships between the various physical properties, and advising on actual practical problems of construction and design. As a result we have now been able to select a few tests on which the greatest number of physical properties of engineering importance depend. We use these tests to compare new soils with those of which we have definite constructional experience.

There is an increasing flood of literature on soil mechanics these days in the technical Press—some printed in German, others in Dutch, Swedish, Russian, and in Calculus. Articles on soil mechanics by mathematicians with no engineering experience and by engineers with shaky laboratory technique must often be read with a certain amount of discrimination.

SOIL BEHAVIOUR

Soils consist of sand, silt, clay, and humus or organic matter. The sand may be silica, and the

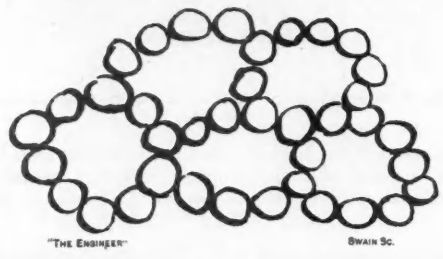


FIG. 2

clay hydrated aluminium silicate; but the names do not depend on chemical composition. Clays owe their behaviour chiefly to the fact that the grains are very small and platy rather than spheroidal. The humus is important chiefly because of its effect on the water-holding capacity of the soil. The fine particles of clay will remain suspended for a long time in water—that is to say, they are colloidal. They have a surface area large compared with their weight, and hence the electrical charges on their surfaces are much more important than the forces of gravity. Small particles of clay may be introduced into a drop of water on the slide of a high-powered microscope, and it will be seen that many of the particles or specks are constantly in motion, darting this way and that—in Brownian movement—due to bumps by molecules of water always in vibration.

It is considered that each colloidal speck is surrounded by a film of liquid which helps to cushion the blow when two particles collide. This film may be charged negatively or positively, and if the charges are altered by adding an electrolyte or by passing a current through the column, the protecting film leaves the particle. On collision they stick together (or "flocculate"), their weight becomes more important than their surface charges, and they sink. This flocculation—or gathering together in flocks—

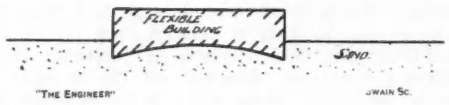


FIG. 3

is well known, whence the use of lime to improve the tilth of the soil in agriculture.

INFLUENCE OF GRAIN SHAPE

There is the famous Reynold's bag experiment. A rubber bag was filled with sand and the stopper opening sealed; the shape of the bag could be easily altered. The voids were then filled with water and the top was sealed. The bag became as solid as a rock. When clay was tried the bag could be deformed due to the sliding of some particles over others. This occurred because the clay grains were platy. This platiness makes the determination of the settling rate of clay particles in suspension rather an arbitrary measurement for the grains with the same horizontal diameter fall at the same rate. We pretend that we are measuring the diameters of spheres.

A very fine or colloidal powder or quartz has no plasticity because the grains are not platy.

INFLUENCE OF GRAIN SIZE

Why does a clay soil hold much more water than sand?

In a suspension column sand grains, under the influence of their weight, roll until they come to depressions and build up a cannon ball structure—Fig. 1. With this formation equal spheres would have a maximum volume of voids of 47·6 per cent. But if the falling particles are very small, the initial friction will check their rolling tendency so that they stick and build up a fairly spongy structure. If colloidal particles are gathered in flocks by means of an electrolyte, the clay forming may have an open texture with 94 per cent. voids—Fig. 2. More water can therefore be retained.

CAPILLARY FORCES

Surface tension at the top of a fine capillary tube will lift water up a considerable height. This tension force or negative hydrostatic pressure has its maximum amount just under the surface of the column. It can be understood that this effect becomes a big factor when there are thousands of these capillaries to a square inch of clay. Of course, in a soil the voids do not form straight tubes. The voids are very small, too, so that the ordinary laws of capillarity and viscosity may not perhaps apply rigorously. In some experiments it was found that for clay with a compressive strength of 740 lb. per square inch the maximum capillary force = 2440 lb. per square inch; for clay with a compressive strength of 1220 lb. per square inch the maximum capillary force = 4840 lb. per square inch. In loading tests there is a difference between the downward vertical load applied and the upward capillary force. The unbalanced pressure forces the water out of the test specimen. Since that volume of water has gone, the particles can move together. In other words, settlement occurs. Since it takes time for the water to go out, settlement may occur slowly.

SHRINKAGE

The shrinkage on drying is stated to be caused by the surface tension existing in the voids of the moist soil and drawing the particles closer. The force may be up to 5000 lb. per square inch, and acts towards the centre of the clay; that is to say, there is a very considerable suction, whence the use of clay beauty packs in removing impurities from the skin. Since the clay has more pore space than a sand, there is more shrinkage in a clay than in a sand. The cohesion across any section of a clay soil is due to this same capillary tension. Dried

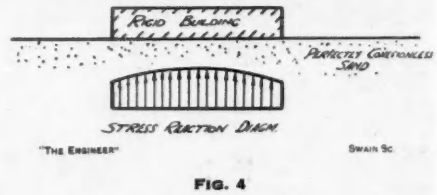


FIG. 4

soils still show cohesion, for the reason that they contain some water which cannot be evaporated.

SWELLING

If the soil be covered with water, the surface tension forces vanish and the specimen swells.

FRICTION

There are several different types of slips possible in sand, and there is no definite single coefficient of friction. A weight resting on a clay surface compresses a clay, the outflowing liquid is trapped and exerts an uplift on the external object. With such a small pressure between the surfaces the friction force is low and the object slips.

FOUNDATIONS

I have read somewhere that 70 per cent. of engineering failures are due to faulty foundations. I think it must be true, too, that many buildings which are standing well to-day have foundations which are oversafe and uneconomical. This does not reflect any discredit on the engineers who have pinned their faith to a 12in. block of hardwood loading test or who have relied on the driving of test piles. It is just that the whole matter is very complex, and as time goes on we are learning a little more about the many factors involved. It is not yet possible to give a completely connected story or to lay down hard and fast rules for the guidance of all engineers, but it is possible to get a little closer than before—perhaps the factor of safety can be decreased from, say, 2½ to 1¾, in a great many cases.

It is not correct to imagine that because 2 tons can be carried on 1 square foot it is only necessary to make a rigid footing slab 100 square feet in area to carry 200 tons. There are too many other factors for us to do that any longer.

The Distribution of Stresses Below a Foundation.—Dr. Terzaghi, of Vienna, assisted by the American Foundation Committee of the American Society of Civil Engineers, has organised a survey of the settlement of a large number of European buildings and structures. In each building he has fixed about twenty brass tubes, into which reference plugs screw, and these are observed at intervals with a water level fitted with a special micrometer. A great deal of interesting information has been collected in this way, and in particular he has found that a building on shallow foundations sinks around the edges—Fig. 3.

This was particularly noticeable with flexible tanks. If the building is quite rigid and cannot

* Paper read at a meeting of the Institute of Petroleum Asphaltic Bitumen Group.

sink more at one place than another, then the soil reactions are least at the sides and greatest in the centre—Fig. 4. (I should mention in passing that clays are the opposite, *e.g.*, a flexible tank behaves as shown in the diagram below—Fig. 5.)

If foundations are placed deeply in sand they tend to behave as clays in this matter of pressure distribution, but there is some doubt on this point. The curved surface that would be produced if the superimposed structure were perfectly flexible and the soil were perfectly uniform is called "the basic form of the settlement trough." Of course, this is seldom completely realised in practice. Where hard spots of soil occur there will be local "pimples" on the "basic trough." Where there are soft spots or where heavy column loads are applied there will be depressions. It is seldom that one meets a "homogeneous" deposit of soil the compressive strength of which does not vary by ± 50 per cent. from the average. It is these variations of upthrust which cause large bending moments and shears in foundation frames. The design of the concrete and steel in the raft involves the deflection of the concrete raft, the distribution of the stresses, and the variability of the soil settlement.

By Boussinesq's mathematical studies it has been shown that soil at a considerable depth is affected by loading—Fig. 6.

Further, Dr. Terzaghi has shown by experiment that 75 per cent. of the total settlement takes place in sand foundations in the territory from $0{\cdot}1\,b$ down to $1{\cdot}8\,b$, where b is half the width of the foundation, *e.g.*, if $2\,b$ is 60ft., the consolidation takes place from 3ft. down to 54ft. The worst foundation failures may occur where there is a strip of compressible clay 50–80ft. underground. So deep exploration is essential for an important structure. The author is of opinion that each large local authority should be equipped with deep

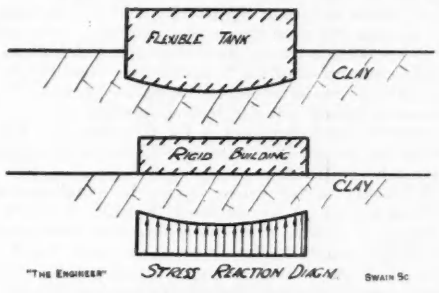


FIG. 5

sampling gear and should make tests at the municipal expense for all buildings of three stories and over.

Ratio of Stress to Settlement.—The majority of soil engineers use a method adopted by Dr. Terzaghi.

A soil pat (undisturbed), obtained with a special sampling device, rests between two porous stones and is compressed by a piston fitted with accurate dials to record the amount of movement. There must be a free outlet for water squeezed out of the pore spaces.

Moisture content, compression settlement, and voids ratio are all closely connected, and one of these is plotted against the pressure in tons per square foot or kilogrammes per square centimetre—Fig. 7.

The voids ratio $= \dfrac{\text{volume of voids in soil}}{\text{volume of solids in soil}}$. This is given the value e_1 when the pressure is p_1, or e_2 when the pressure is p_2.

Then total settlement under foundation

$$Q = D_1 \times \frac{e_1 - e_2}{1 + e_1},$$

where D_1 = thickness of soil layer under pressure p_1.

For example, in a case given by Hogentogler, e changes from 2·37 to 1·52 when the total load changes from $\frac{1}{2}$ ton to 3 tons per square foot. So that if 3 tons per square foot rests on this muck soil (5ft. thick), the total settlement will be

$$Q = \frac{2{\cdot}37 - 1{\cdot}52}{1 + 2{\cdot}37} \times 5\text{ft.} = 1{\cdot}26\text{ft.} = 15\text{in. (say).}$$

The rate of settlement can be calculated from measuring the speed at which water passes through the soil and making a correction according to the ratio of thickness of soil layer in the field to thickness of soil sample in the laboratory. Professor Buisman finds that when compression settlements are plotted against the logarithm of the time in minutes, a straight line is obtained. He then very bravely predicts how much a building will settle in ten centuries.

A variation of the general method of calculation is used by the Foundation Soils Research Laboratory in Cairo. They find Young's modulus for the soil by loading it in an oedometer. Then the actual Young's modulus in the field is taken to be from $1\frac{1}{2}$ to 4 times this, according to the class of soil. Then for a given stress the strain can be calculated. The stress is the weight of the building per square foot of foundation at a given depth, and the strain is the settlement divided by the thickness of the oil stratum. Fourteen buildings are under observation for settlement in Cairo—this in spite of some reluctance by engineers, architects, and builders who maintained that their buildings were so well designed and constructed as to be free from the least settlement.

Another method is that formulated by Professor Housel, Michigan. He shows, by loading various sizes and shapes of steel plates, that a foundation is held up by two things:

(1) The pressure in pounds per square foot on its flat surface; and

(2) The shearing force and skin friction force on its sides.

By taking three or four size foundation tests it is possible to affix values to each of these effects, and so calculate the safe bearing value for a larger area. A soil may carry 1 ton on 1 square foot, but only 3 tons on 6 square feet.

ROADS

The United States Bureau of Public Roads has done a great deal of valuable pioneering work in subgrade soils. The Bureau classifies the soils into eight groups, according to mechanical analysis, plasticity limits, lineal shrinkage, and moisture

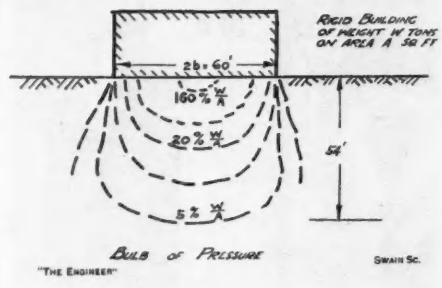


FIG. 6

equivalent tests, and prescribes a treatment and design for each of those types of soil. One example should suffice.

For example, "Group A-5 subgrades have a shrinkage limit likely to be greater than 30 and a high moisture equivalent. Exceptions occur—the liquid limit is usually larger than 35, but may be less than 25. Roads on this soil provide elastic riding. Compaction with a heavy roller is apt to cause non-uniform rebound of the soil during pavement construction. Drainage must be provided to intercept seepage and reduce the adverse effects of frost heave. In the treatment a bituminous application should be followed by a cushion and a porous base course. Clay may be added with good results. Macadam should not be used until the subgrade has been stabilised by both treatment and drainage."

There is still a certain vagueness in the classification. It is full of such terms as "may be," "usually," "likely to be," and in practice it will be found that the test values for a soil "usually" permit it being placed in two or even three groups out of the eight. The author feels that this is because several of the

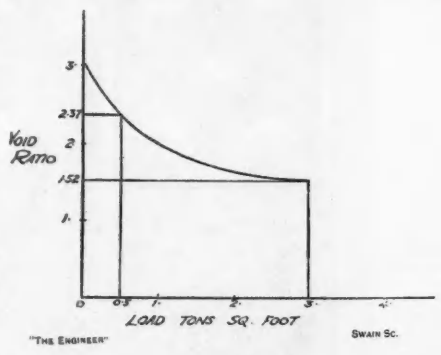


FIG. 7

tests chosen measure properties only rather indirectly connected with road construction practice. You can take just that portion of the soil which passes the 40-mesh sieve and find what moisture content it will have when you can roll it in a thread the size of a match—that is, find the lower plastic limit. Or you can find how many times you must knock a dish in a certain way to make a crack in the soil heal up along 1 mm. of height—that is, find the lower liquid limit. You are measuring something about a portion only of the soil under forces and conditions with no proved theoretical or practical relationship to ordinary road engineering. The other two tests employed—centrifuge moisture equivalent and shrinkage limit—although presenting some laboratory difficulties, have a more definite connection with practice; but the Bureau classification tests make no attempt at finding the properties most important to the road engineer—the strength of the soil in tension, compression, or shear. The author does not suggest that the Atterberg plasticity tests be discarded, only that they should be supplemented for classification purposes.

Road subgrade design has been important in New Zealand, because thousands of miles of the county roads and highways run through districts which cannot as yet afford to provide bituminous, tar, or concrete wearing surfaces. The development of fast motor traffic has therefore created a demand for a strong stone macadam or metalled road, as we call it, which will not crush, ravel, or corrugate, in wet or dry weather, under 100 or 1000 vehicles per day. Briefly, the early practice was to use spawls of stone from 3in. to 6in., blinded with quarry stone from $1\frac{1}{2}$in. to $\frac{1}{2}$in. By about 1915 all stone had to pass a $2\frac{1}{2}$in. ring. In 1920 advanced county engineers were ordering 2in. to dust metal and putting in an 8in. thickness. In 1928 the engineers demanded so many tons of $1\frac{1}{2}$–$\frac{3}{4}$, so many $\frac{3}{4}$–$\frac{1}{2}$, $\frac{1}{2}$–$\frac{1}{4}$, and so many tons $\frac{1}{4}$ to dust. In 1936 the New Zealand Main Highways Board advised for important roads that the soil mortar material passing 10 mesh must have a tensile strength of at least 15 lb. per square inch, a lineal shrinkage of less than 5 per cent., and must have at least 25 per cent. passing 200 mesh. Corrugations will form wherever the subgrade is low in tensile strength, and frost heave or swelling will occur if the lineal shrinkage is too great. Bases of concrete, bituminous, or tar roads are designed on the same principle, and in many cases it is considered sufficient to use a 4in. thickness of graded stone and sand clay in order to carry a $1\frac{1}{2}$in. wearing coat for secondary main highways. The stone, sand, and clay are watered and thoroughly mixed on the road by auto patrol graders. Traffic may be used for consolidation when the clay content is sufficiently high.

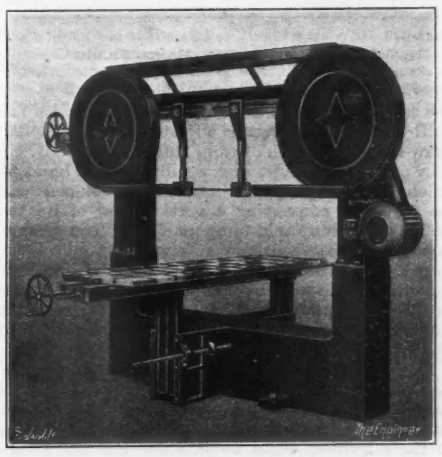
A further development of road subgrade design is the use of bituminously stabilised soil in this country, where the high compressive strength of a dried sand clay is maintained by bituminous emulsion waterproofing. Since the natural materials are used *in situ* there is little cost for excavation and little cost in the haulage of materials to the site. Speed of construction is of the order of $1\frac{1}{2}$ acres per day. There are a large number of practical points to be watched in the design and construction of stabilised soil roads, car parks, and aerodromes, points such as the choice of aggregates, design and control of mixes, surveying, drainage, choice of plant, organisation of labour, and the variation of the process under changing weather conditions.

In general, progress in soil mechanics can be achieved only by a close co-ordination of accurate laboratory work and vigorous civil engineering work in the field. In addition, there must always be intermediate tests—large-scale laboratory specimens and small field experiments to make a continuous connection between the laboratory and the job. Only in this way can we hope to avoid the errors which lie in wait for a pure theorist or a science despising foreman.

Horizontal Bandsaw for Non-Ferrous Metals

THE horizontal bandsaw illustrated herewith is a recent addition to the products of the Midland Saw and Tool Company, Ltd., Pope Street, Birmingham, and is primarily intended for cutting aluminium or magnesium alloy castings the size or shape of which makes it difficult to handle them on a vertical bandsaw.

The framework consists of a box-sectional base carrying two vertical posts which are united at the



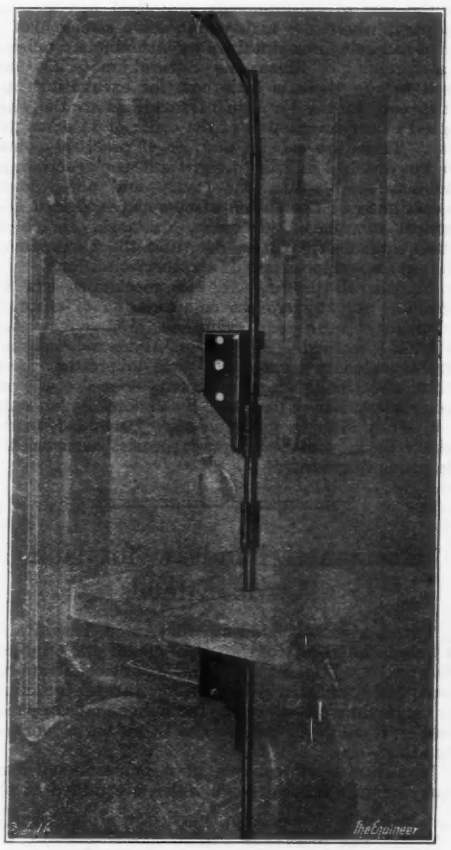
HORIZONTAL BANDSAW

top by a U-sectioned cross piece. The table is carried on two vertical slides, 42in. apart, and is raised and lowered by means of a fixed screw and a revolving nut in each slide, the two nuts being operated in unison from a hand wheel on a shaft projecting to the front of the machine. Work pieces are clamped to the table by means of nine crosswise and two lengthwise tee-slots. The movement of the table on the top slide is effected by an arrangement consisting of a fixed screw extending beneath the table for its

whole length and a revolving nut coupled through pinions to two horizontal operating rods, one of which applies slow and the other fast traverse to the table.

The saw wheels are of the makers' standard design with vulcanised rubber treads. They are carried on spigo ted hubs and can be interchanged without dismounting the spindles. The wheels are fitted with rigid guards on their faces and round their peripheries. A fixed box guard completely encloses the upper part of the saw and two horizontally adjustable guards are provided for the lower part. Two guides with long non-metallic supports are mounted adjustably on the U-sectioned cross member of the frame and guide the saw at the working portion. The saw is fitted with a spring-tensioning device and with a tracking arrangement which can be operated by hand while the machine is in motion. The driving motor is mounted on a vertical plate on the right-hand column and transmits power through vee ropes which are s itably guarded. Control gear is mounted adjacent to the motor.

The height of the machine from the floor to the centre of the wheels is 67in., and the maximum and minimum distances between the wheel centres are 82in. and 78in. The saw guides may be adjusted from zero up to a distance of 48in. apart. The table height above the floor can be varied from 22in. to 40in., and the distance between the table and the saw from 12in. to 30in. The table measures 58½in. long by 30in. wide, and has a movement of 48in.



ARRANGEMENT FOR BAND FILING

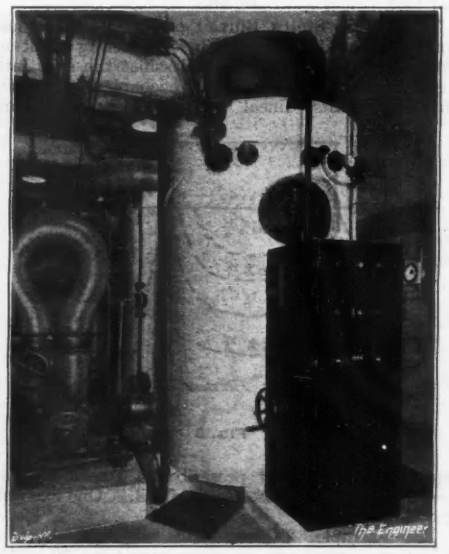
The saw wheels have a diameter of 30in. and a face width of 2in. They can be adjusted to accommodate a saw having a length of from 20ft. 10in. to 21ft. 6in.

In our second engraving we illustrate a band file which the company has recently developed with the object of converting a vertical saw of its tool room type into a rapid filing machine. The arrangement provides continuous one-direction cutting for which several advantages are claimed, including reduction of file wear by elimination of the backward stroke accompanying filing with a reciprocating motion, and the avoidance of the necessity for cumbersome holding-down mechanism for the work.

The device consists of a number of files mounted on a steel band made endless by means of a keyhole coupling. The files are aligned automatically on the band by locating pins, and are cut to an angle at their leading edges to increase the smoothness of their entry into the work. A hardened steel guide, 24in. in length, is carried on brackets attached to the body of the machine, and takes the working thrust of the band file. This guide permits the table to be tilted in any direction without interference. Side support for the band file is provided along the length of the guide over a distance of 9½in., which is the maximum width of work admitted. For thinner work an additional guide is provided to give support along the above-named distance of 9½in. The band file may have a width of ¼in., ⅜in., or ½in. Flat or contoured files can be provided for filing ferrous or non-ferrous metals.

Electrode Thermal Storage Equipment at Poplar Town Hall

At the Town Hall of the Metropolitan Borough of Poplar the heating and air-conditioning systems are served by an electric thermal-storage plant. There are two 650-kW electrode circulators directly connected to a 6·6-kV, three-phase supply, each heater having its own automatic control cubicle and high-voltage solenoid operated oil circuit breaker. A main indicating panel is also provided. When operating, on an "off peak" supply, the system is designed to provide a full day's heating and two 15,000-gallon storage cylinders, working between the temperature



ONE OF THE 650-KW ELECTRODE CIRCULATORS

limits of 150 deg. and 240 deg. Fah., store heat for the "cut-off" period.

The two high-voltage vertical electrode circulators, are designed for load adjustment by raising or lowering the electrode shields by means of motors driving through reduction gearing, a method of regulation which enables wide load regulation to be obtained with water having a resistance varying in the ratio of 4·25 to 1 with temperature rise. Various automatic and safety devices control the motors operating the electrode shields and the interconnection of these motors with the control devices ensures that the load is reduced to a small value before the main circuit is either made or broken by the oil switch. Load regulation is automatic, and is controlled by special regulating relays, which can be set to give a constant loading of 30, 45, 85, or 100 per cent. of full load on each boiler. Besides the automatic controls there is a push button fitted to the control cubicle and by means of this button the load can be regulated by hand.

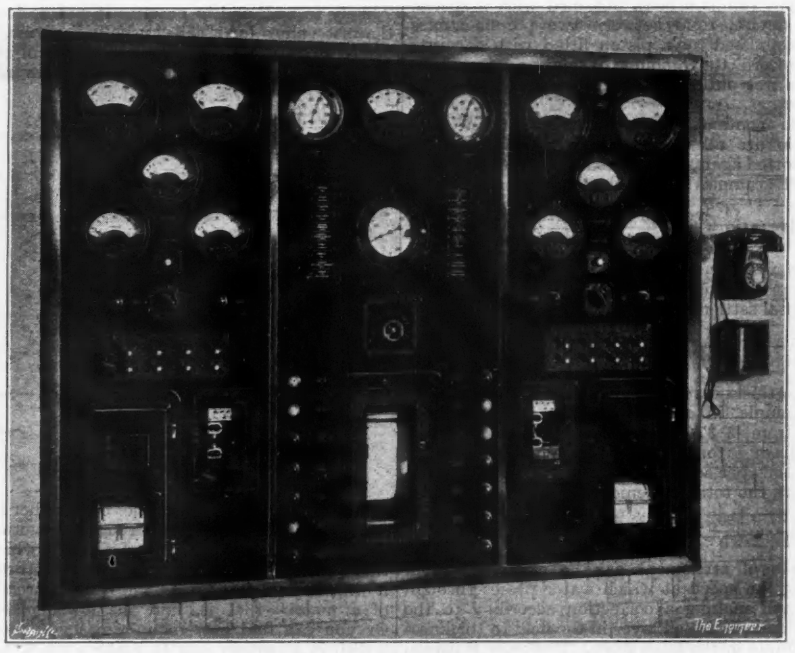
Water circulation between the circulators and storage cylinders is obtained by a motor-driven pump, and the primary pipe work is arranged so that either circulator can be used with either storage cylinder. Between the primary flow and the return connections of the circulator is a by-pass pipe, carrying a water flow supply relay which remains open until the pumps start, thus giving protection against excess temperatures in the circulator, whilst to minimise the range of temperature over the whole of the storage heating period, primary mixing valves are fitted to the primary pipe work.

Another object of these valves is to allow water of any desired temperature to be passed to the top of the storage cylinders, so that in the case of emergency hot water can be made available for use, even if the bulk of the water is at a low temperature. These valves are electrically operated by thermostats and solenoids, and provide for the recirculation in the heaters until the water temperature reaches a predetermined value, controlled by a thermostat with a wide range of adjustment. Separate solenoid operated thermostatically controlled mixing valves control the temperature of the water circulating through the radiator system and air-conditioning heater batteries.

Protective devices deal with electric and hydraulic faults, such as out-of-balance load, excess current, excess temperature, excess pressure, failure of pump motors or loss of heat. The occurrence of any one of these faults is shown by the fault-indicating relays mounted on the indicating panel, the relays having lock-outs for preventing the circulators being reconnected to the supply until the fault is cleared.

The indicating board, composed of three panels, carries on the central panel a twenty-point electric indicating thermometer for giving central readings of the air temperature in the various parts of the building and water temperatures at various points on the primary and secondary pipe work. On this part of the panel there are also indicating lamps to show which motors of the heating and air-conditioning pumps and fans are in use. On the lower part of the panel is a temperature recorder, which gives a continuous record of the temperature of the flow and return water in the secondary regulating system. The two side panels are for the circulators and carry ammeters and voltmeters, a fault indicator, a kilowatt-hour meter, and recorder, together with a push button for starting.

Adjacent to the boiler house is a sub-station equipped with a seven-panel 6·6-kV metal-clad "subgear" board, with circuit breakers controlling the power supply to the electrode circulators and to two 300-kVA, 6·6-kV–400-volt transformers, which supply auxiliaries and general house service. Throughout the building the hot water service is provided by G.E.C. storage water heaters of the self-contained cistern type. The complete installation was supplied by the General Electric Company, Ltd., of Magnet House, Kingsway, W.C.2. We are indebted to Mr. R. Illingsworth, chief engineer to the Poplar Borough Council, for permission to publish this description. Mr. J. Roger Preston was the consulting engineer, and Messrs. V. Smith and Co., heating engineers, carried out the installation work.



INDICATING PANEL

PARSONS MEMORIAL LECTURE.—It is announced by the North-East Coast Institution of Engineers and Shipbuilders that this year's Parsons Memorial Lecture will be delivered by Sir Stephen J. Pigott.

The Rational Design of Load-Bearing Brickwork

It is well known that structures in which the load-bearing members are of reinforced concrete or steel are always rationally designed. That is to say, the form and dimensions of columns, girders, beams, and associated members are all determined by calculations based upon the mechanical properties of the structural material itself. What is not so well known is that all modern building regulations also contain clauses governing a similar application of rational design to load-bearing brickwork.

To summarise briefly the sense of those clauses, seven classes of brick, ranging in compressive strength from 1500 lb. per square inch upwards, may be used for load-bearing brickwork in conjunction with a series of mortars, ranging from lime mortar up to 1 : 2 cement mortar. For each of the seven classes of brick, when laid up in any one of the specified mortars, a maximum load-bearing capacity is laid down. Hence structural members, such as brickwork walls, piers, and columns, can be rationally designed by calculations based upon the mechanical properties of the brickwork. The maximum permissible stresses which are common to both the current L.C.C. Building By-laws and the Ministry of Health Model By-laws are summarised in the following table :—

Maximum Pressures Permissible on Walls and Columns Constructed in Various Types of Brickwork and having a Slenderness Ratio of 6 or less.

Wet brick strength, lb. per sq. in., not less than	Mortar composition by volume.			Maximum* permissible load in tons per sq. ft.
	Cement.	Lime.	Sand.	
1,500	1	1	6	7
1,500	1	—	4	8
3,000	1	1	6	10
3,000	1	—	4	11
4,000	1	—	3	13·5
5,000	1	—	3	16
7,500	1	—	2½	23
10,000	1	—	2½	30
Over 10,000, say, M	1	—	2	$\frac{M}{500}+10$, but not greater than 40

* The Ministry of Health By-laws allow a 50 per cent. excess where loading is a combination of uniformly distributed, excentric, and concentrated loads, provided average pressure does not exceed that tabulated above.

It must be noted that the stresses tabulated here are permissible only when the "slenderness ratio" is 6 or less, and must be reduced *pro rata* as the "slenderness ratio" of the wall or column increases from 6 to 12. This reduction amounts to 60 per cent. when the maximum permissible "slenderness ratio" (12) is reached. The "slenderness ratio" of any storey height of a wall or column is defined, in the L.C.C. by-laws, as the ratio of "effective height" to the horizontal cross-sectional dimension of the member which lies in the direction of the lateral support (if any) at the head of the wall or column. When laterally supported, the "effective height" of a wall is three-fourths of the actual storey height ; of a column, the actual storey height. When not so supported, to get the "effective height" the actual storey height must be multiplied by 1½ or 2 respectively.

From this outline of rational brickwork design procedure, as officially recognised, it is clear that to arrive at a suitable design the architect or engineer has first to carry out a series of arithmetical conversions (for any proposed storey height) for each of the types of brickwork possible when the seven classes of brick are associated with the various specified types of mortar. The arithmetical work gets more tedious still when the proposed cross section, storey height, and type of brickwork are varied simultaneously, so as to arrive at, say, a minimum cross section, minimum cost, maximum storey height with a given brick or some other data of immediate practical value.

The Clay Products Technical Bureau of Great Britain has therefore prepared a series of charts, from which can be read straight off the actual practical answer to any specific problem which may arise in the design of load-bearing brickwork in accordance with building regulations. The first two of these charts, dealing with walls and columns respectively, are now published. They deal with the more usual types of load-bearing brickwork only, *i.e.*, those types which can be constructed with ordinary bricks of average strengths (1500–5000 lb. per square inch), in association with mortars giving reasonable load-bearing capacities. Storey heights up to 24ft. for walls and 18ft. for columns are given inch by inch ; wall thicknesses and column dimensions up to 18in. and loads up to 36 tons. Five typical examples illustrating their use are also given.

Copies of these open scale, easily read charts, which are printed side by side on one 34in. by 22in. sheet, suitable for fixing to a drawing-office wall, are obtainable from the Clay Products Technical Bureau of Great Britain, Ltd., 90, Ebury Street, London, S.W.1.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

The War Priority System

The Select Committee on National Expenditure has issued its tenth report, which deals with the priority organisation. The report states that materials and production dominate the picture and therefore it deals with the working of the priority system in relation to materials and capacity. The main criticisms which have been levelled at the existing central priority organisation do not spring from any failure on its part to carry out the work for which it was designed, but from the single allegation that the conception of the problem was too limited, with the result that only part of the field has been covered and the system is thus incomplete. The report points out that the complete priority system should regulate the whole process from the originating demand to the supply of the finished product in such a way that the entire national resources would be organised to secure not only a balanced maximum output, but the priority grading relative to the use of the product in the war effort. From what the Committee has heard and seen, says the report, they "can only conclude that neither the rationing system, which places the available capacity and materials at the disposal of separate supply departments in accordance with estimated requirements, nor the general priority direction secures that the output of articles is regulated in terms of the urgency for which they are required to be brought into use." Finally, the report contains a summary of the recommendations of the Sub-Committee to the Select Committee, which include the following :—The setting up of an extra departmental body with powers to compel consuming departments where future difficulties of supplies are foreseen to modify their specifications or their quantitative requirements in advance of these difficulties ; the establishment of full inter-departmental co-ordination ; the establishment of an independent department comprising the priority organisation and the raw material controls with overriding powers in the priority field ; that priority directions should be drawn up for specified periods (not less than three months), based on detailed planning of the supplies and needs of the war departments ; that a system of priority and grading should be established immediately ; that independent priority certificates should be granted to main contractors and sub-contractors. Recommendations regarding a progressing organisation have apparently been largely met in advance by the Ministry of Supply, according to an addendum to the report.

Unauthorised Use of Symbols

The following notice has been issued by the Iron and Steel Control :—"It has come to the notice of the Control that a number of contractors have been using symbols without first obtaining the written authorisation of the department concerned. In some cases failure to obtain the necessary authority has resulted in contractors using the wrong symbols. The Iron and Steel Control points out that in every case sanction, in writing, should be obtained from the appropriate department before applying a symbol to a job or jobs. Sub-contractors should obtain written confirmation from the main contractors. A serious view will be taken in future by the Ministry of Supply of any failure to comply with these regulations."

The Pig Iron Market

The position in the pig iron market has not materially changed, and whilst supplies are available for firms engaged upon work of national importance, it is only by careful distribution that consumers are ensured regular deliveries. The demand in the foundry iron department appears to be gradually expanding. The quantities of high-phosphoric foundry iron available are sufficient to meet the requirements of the consuming trades, but after these have been satisfied there is little margin. A number of light castings foundries have now been put on to war production, and as a result larger quantities of high-phosphoric iron are being taken up. There is a noticeable stringency in supplies of low-phosphoric iron and hematite grades, the tightness being greater in the latter department. Large tonnages of low-phosphoric iron are passing into consumption at the engineering foundries employed on war work, and stocks have fallen to a low level. The policy of the Control, however, is not to help consumers to build up reserves, since all the production is required immediately it becomes available. It is understood that up to the present purchases of low-phosphoric iron from abroad have not been made by the Control, but it is possible that if the demand grows this course will be adopted. The production in this country is on a good scale, but there seems to be some difficulty in obtaining suitable ores. Supplies of hematite are carefully allocated to users. Practically only those firms engaged upon national work can obtain licences for this description.

Scotland and the North

With great regularity huge tonnages of steel are being produced by the heavy steel works in Scotland. The supply of raw materials is satisfactory, although there is a little unevenness in the deliveries of scrap. Consumers' requirements, however, are on such a scale that every ton of manufactured steel passes at once into consumption. All classes of users are urgently pressing their needs upon the steel works and the demand now embraces all descriptions of iron and steel products. The situation shows some change, however, and whereas not long ago it was almost impossible to obtain steel for the manufacture of goods for export, the most urgent requirements of the Government appear to have been satisfied to the extent that a certain amount of steel is now available for this purpose. It will be some time, however, before the position is sufficiently easy to enable liberal tonnages to be allocated to the export trades. The Scottish shipyards are taking up large quantities of steel and pressure from this industry to obtain supplies does not tend to diminish. The requirements of the structural engineers who are heavily engaged upon Government contracts are also well maintained and the general engineering concerns miss no opportunity of securing all the steel they can get. The Lancashire consumers are working under extreme pressure and they in turn are exercising great pressure upon the steel works to obtain their supplies. Manufacturers of electrical plant are extremely busy and as much of their work is on Government account they are receiving heavy deliveries. Their needs represent large tonnages of bars, plates and sections, whilst plates are also in strong demand from locomotive builders and tank and boilermakers. There is an increasing demand for special and alloy steels.

The Midlands and South Wales

Great activity continues to rule in the Midland iron and steel trades. Although the position is believed to be getting easier, very little steel material is available for ordinary commercial purposes. By far the greater part of the output is going to fill Government requirements, but even so a certain number of delays in delivery are reported. Great efforts are being made to allocate a percentage of steel to the trades making exportable products, but this outlet also is limited by the necessity of satisfying urgent Government needs. Whilst there have been considerable supplies of semis distributed, there appears to be some stringency in the quantities of 2in. billets available, but it is understood that this is only a temporary difficulty and is likely to be overcome in the near future. All the steel works are experiencing incessant pressure from consumers anxious to obtain material, but everything is governed by the Control, which regulates deliveries according to the importance of the work in hand. There is a heavy demand from the constructional engineers and the steel requirements of the shipyards have not lessened within recent weeks. The plate mills are producing at top pressure, but some stringency in supplies is noticeable and even firms engaged upon important work find a difficulty in obtaining their full requirements. Large quantities of plates are being consumed by the shipbuilders, tank makers and locomotive and wagon builders, and, considering the enormous tonnages passing into consumption, it is not surprising that some delays in delivery are reported. The sheet works continue to maintain large outputs of black and galvanised sheets, the greater part of which are urgently required by firms employed on Government contracts. In South Wales all the iron and steel works are engaged almost to the exclusion of other work upon orders of national importance. The tin-plate mills have orders for about six million boxes upon their books, but latterly their allocation of steel has been reduced in order to meet the demands of other industries, and for the time being they are unable to overtake these contracts.

Copper and Tin

The copper market in this country displays no fresh feature. In the absence of any statistics it is difficult to obtain an accurate estimate of the position, but so far as can be seen there is no stringency, and firms engaged upon war work are obtaining all the metal they need. Since practically all manufacturers of copper products are engaged in this class of work, the consumption must be enormous. Arrivals from Empire countries are regular, and in addition the United States is supplying considerable quantities of manufactured copper and brass. In the United States market conditions remain steady, but domestic consumption is at a rather low point, although there are observers who believe that the American rearmament programme is beginning to influence the demand. The United States official domestic price is 11c., but sales have been made by Customs smelters at 10·75c. The American export price remains at 9·90c., f.a.s. American statistics give the output of refined copper in June as 90,995 tons, compared with 86,077 tons in the previous month. The deliveries during the month were 71,226 tons, against 61,716 tons in May. The exports in June were 3532 tons, compared with 3439 tons in the previous month. Stocks of copper at the end of June totalled 215,823 tons, against 199,586 tons at the end of May.... The tin market has been rather uninteresting and prices have shown an easier tendency. In the United States the price, after being somewhat firmer, has slipped back to within ¼c. of the American Government's price of 50c. It is said that some tin has been sold to the Metals Reserve Corporation—the American Government's buying agency—and no doubt when the opportunity occurs further purchases will be made.

Lead and Spelter

The lead position in Britain seems comfortable and users requiring metal for reasonable uses have little difficulty in obtaining it. In the United States the reduction in the price from 5c. to 4·75c. appears to have been the result of some sales of Mexican lead in that country. Probably the producers, in lowering their quotation, did so with the object of preventing further imports. The situation of the Mexican mines appears to be rather serious, since outside the United States few markets are left. Most of their pre-war output was sent to those parts of the Continent which are now overrun by Germany. The Mexican lead industry is largely in the hands of American firms, and to add to their troubles there seems a danger that the properties may be expropriated if they are unable to keep them in operation.... With large quantities of spelter passing into consumption the position is rather tighter than in lead. Supplies from Empire sources, however, are sufficient to enable the war effort to be maintained without difficulty. Consumers requiring spelter for other than war uses do not find it easy to cover their orders, but firms engaged upon national work are obtaining full supplies. Most users are fully employed and the brassmakers in particular are taking up large tonnages. The galvanisers also are busy and their demands are an important factor in the market. Efforts are being made to provide firms making exportable products, with more metal.

Notes and Memoranda

Rail and Road

L.N.E.R. FERRY SERVICE WITHDRAWN.—It is announced by the London and North-Eastern Railway Company that the hourly ferry service between Harwich and Felixtowe dock has been withdrawn. The last sailing was made from Felixtowe dock to Harwich on Monday evening, August 19th.

MOTOR-CAR NOISES.—Through the Noise Abatement League, an appeal has been made by the Hon. Secretary, Sir Christopher Robinson, to drivers of motor cars and lorries. They are asked not to accelerate on low gear, especially after dark, because the high-pitched ascending note sounds exactly like an air raid siren.

GREAT WESTERN RAILWAY APPOINTMENTS.—Mr. R. Dixon, formerly of Cardiff, has been appointed the manager of the Great Western Railway Company's docks at Milbay, Plymouth, consequent on the retirement of Mr. E. W. Gould. Mr. Dixon was previously the head of the commercial department of the chief docks manager's office, Great Western Railway, Cardiff. Mr. A. C. Morris, who was formerly chief timber measurer at Cardiff docks, has been appointed chief clerk in succession to Mr. Ivor Thomas, who has been transferred to a port in South Wales.

PETROL RATIONING AND PRODUCER GAS VEHICLES IN FRANCE.—Present stocks of petrol in France are sufficient to last barely five weeks, states a message from Vichy. Accordingly, the French Government has imposed drastic rationing. Only vehicles on public services or used by doctors will be allowed on the roads in future, and the vehicles of all those who violate the order will be confiscated. Charcoal gas equipment for vehicles is to be manufactured by the aircraft factories at Limoges, and the Peugeot, Citroen, and Renault factories will re-open to manufacture charcoal-burning cars.

NEW ROLLING STOCK ON AMERICAN RAILWAYS.—American Class I railways put 36,852 new freight wagons in service in the first six months of 1940, according to the Association of American Railroads. This was the largest number installed in any corresponding period since 1930, when 49,208 new wagons were put in service. In the first half of 1939 there were 8628 new freight wagons installed. Of the total number of new freight wagons placed in operation in the six months' period this year, coal wagons numbered 19,076; box, 16,007; refrigerator, 595; flat, 569; stock, 88, and miscellaneous, 517. At the same time, the railways installed in service 180 new locomotives, of which 45 were steam and 135 were electric and diesel-electric. Installed in the first six months in 1939 were 126 new locomotives, of which 16 were steam and 110 were electric and diesel-electric.

AMERICAN "400" DIESEL-ELECTRIC LOCOMOTIVES.—Two 4000 H.P. Diesel-electric locomotives which the Chicago and North-Western uses on its "400" and its North-Western Limited between Chicago and the Twin Cities, completed 300,000 miles each in continuous service on July 13th. The locomotives were delivered in May and June, 1939, and after test runs were used on the North-Western Limited in July, August, and September. With the placing in service of the new "400" on September 24th, 1939, they were also assigned to the "400" on a schedule which provides for morning arrival at each terminal with the North-Western Limited and afternoon departure with the "400." The *Railway Age* states that as a result each of these locomotives has travelled 861 miles per day since September 24th, 1939, and has been on the road 16 h. 35 min. in each twenty-four hours.

NEW CANADIAN HIGHWAY.—The Queen Elizabeth Way, Canada's first express highway, should by now be complete over a stretch of 75 miles between Toronto and Niagara Falls. This portion of the new highway, according to a recent statement of the Minister of Highways for Ontario, was to have been finished in time for the opening at Toronto of the Canadian National Exhibition. A section 25 miles long south of Toronto is now in use. The highway is of the dual-lane pattern, and it is reported that as much as 20,000ft. of single lane roadway is being laid a day. Planned to relieve congestion on the Niagara Peninsula, through which more than half Canada's tourists enter the country, the Queen Elizabeth Way is the first of a projected series of dual-lane express highways, which are expected to be completed by 1960. It has been built at a cost of approximately 120,000 dollars a mile, or about 11,000,000 dollars for the entire 91 miles.

Air and Water

THE LATE MR. A. R. MOUNTAIN.—We regret to note the death of Mr. Arthur Reginald Mountain, Chairman of Lloyd's in 1929, which took place on Tuesday, August 20th, at the age of sixty-three.

AIR RAID PRECAUTIONS IN SHIPS.—An Order has been issued by the Admiralty requiring that there shall always be aboard any merchant ship which is in harbour sufficient men who are able to man the ship's fire-fighting appliances. The Order applies to all merchant ships, both British and foreign, whether they are manned by a crew on articles or not.

BELGIAN COASTING AND TRAMP SHIPS.—It is announced that on behalf of the Belgian Embassy, Mr. H. J. S. Harper, the managing director of the John Cockerill Line, of 37, Mark Lane, London, E.C.3, has been appointed the manager and controller of fifteen Belgian coasting and tramp steamers. Brokers who are interested in Belgian ships are asked to get into touch with Mr. Harper.

SCOTTISH R.A.F. SELECTION BOARD.—A new Scottish Selection Board for the Royal Air Force was opened on Monday last, August 19th, at Savings Bank Buildings, Hanover Street, Edinburgh, under the presidency of Group Captain C. R. Keary. The Board will save young candidates from Scotland the necessity of travelling to London for their interviews. On the first four days of each week candidates for air crew duties, in other than commissioned ranks, such as pilots, observers, and wireless operator air gunners, will be seen. Fridays and Saturdays will be set apart for the selection of direct-entry officers into the R.A.F. Volunteer Reserve.

A SAN FRANCISCO TO NEW ZEALAND FLIGHT.—The American flying boat "Clipper" arrived in Auckland, New Zealand, on Friday, August 16th, inaugurating the new 8000-mile transoceanic service of the Southern Pacific from San Francisco to New Zealand. On her arrival the boat was officially met on behalf of the Government by Mr. W. Nash, the Finance Minister.

MERCANTILE LOSSES.—During the week ended Sunday, August 11th, the mercantile losses due to enemy action included nine British ships totalling 32,257 tons and one Allied ship of 942 tons. Two neutral ships, aggregating 6708 tons, were sunk during the week under review, making a combined total of twelve ships aggregating 39,907 tons. This figure is much below that for the previous week.

THE "CLARE'S" SECOND ATLANTIC FLIGHT.—It was announced from New York on Friday last, August 16th, that the 23-ton British Overseas Airways Corporation's flying boat "Clare" arrived at an early hour on the La Guardia airfield, New York, having completed her second east to west Transatlantic crossing within twelve days. The journey took just over 29 hours. The "Clare" left Foynes at 7.45 p.m. on Wednesday, and reached New York at 12.50 a.m., B.S.T., on Friday. One of the passengers was Captain H. H. Balfour, the Under-Secretary for Air, who is making visits to Canada and Washington. On the return journey the "Clare" arrived at Foynes at 11.35 a.m., B.S.T., on Tuesday last, having made the crossing from Botwood, Newfoundland, in 13 hours 52 minutes.

NAVAL VACANCIES FOR MOTORBOAT HANDS.—The Admiralty announces a limited number of vacancies in the Royal Navy for men with experience in the handling of fast seagoing motorboats for employment principally round the coasts of the British Isles. Candidates will be entered in the Royal Navy Patrol Service as second hands and enginemen, both carrying the status of Petty Officer. Rates of pay are:—Second hands, 6s. per day, and enginemen, 6s. 11d. Usual naval allowances are also payable. Volunteers should apply to local registrars, Royal Naval Reserve, taking with them evidence that they have had experience of fast seagoing motorboats of a speed of 15 knots or more. Men who at registration have expressed a preference for naval service can be accepted.

THE LATE CAPTAIN CHRISTEN SMITH.—We regret to announce the death of Captain Christen Smith, managing director of the Norwegian shipping company, Belships, Ltd., of Victoria Street, London. Captain Smith, who was formerly an officer in the Norwegian Navy, was an expert in heavy lifts. Soon after the last war he ordered a special ship to carry railway carriages, locomotives, and even lightships and tugs. His venture was so successful that he soon had a fleet of motorships, all of which were built by Armstrong, Whitworth, of Newcastle. They all had the prefix "Bel," and became known the world over as the Belship fleet. Since 1921 nearly 200 shipments have been handled with complete success. He employed an expert staff, which always worked out the intricate calculations connected with the carrying of the cargoes, and which, no doubt, contributed greatly to the success of the firm.

Miscellanea

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.—The Incorporated Municipal Electrical Association, which represents all the local authorities owning electricity undertakings in Great Britain and Northern Ireland, has, as a gesture, offered to H.M. Government the interest accruing on Government securities at present held by the Association, amounting to £10,000, for the duration of the war.

NEW TIMBER CONTROL ORDERS.—Three new Timber Control Orders have been made by the Ministry of Supply. The first requires the rendering of returns monthly of all charges payable in connection with the use or consumption of imported timber. The second defines second-hand timber and the methods for determining the price payable for such timber, and the third brings into operation increased prices for plywood.

CITY AND GUILDS OF LONDON INSTITUTE.—The Council of the City and Guilds of London Institute has conferred the distinction of Fellow of the Institute (F.C.G.I.) upon the following gentlemen:—Mr. H. C. Armstrong, M.Ins.C.E.; Mr. C. H. Desch, D.Sc. (Lond.), Ph.D. (Würzburg), F.R.S., F.I.C., F.I.Ph.; Mr. A. P. M. Fleming, O.B.E., C.B.E., D.Eng., M.Sc., M.I.E.E., M.I. Mech. E., F. Inst. P., F. Amer. I.E.E.; Mr. S. L. Smith, D.Sc., M.I. Mech. E., M. Inst. C.E.

AN AMERICAN SEWAGE PLANT.—Two years ago the construction was started of a new sewage disposal and treatment plant at Rock Island, Illinois, and we now learn that the plant has been officially opened. Municipal wastes of all kinds are to be treated by primary sedimentation followed by magnetite sand filtration. Garbage is arranged to be ground and sludge and trash burnt. An interesting provision is storage in the form of two spherical tanks for sludge gas, which is to be used as fuel for operating the plant. The plant has cost about 3,000,000 dollars.

MUSIC IN WORKSHOPS.—We learn from Automotive Products Company, Ltd., that all its factories have been fitted out with equipment for the radiation of gramophone records, broadcast programmes, and general addresses. Each factory is fitted with its own specialised distribution of loud speakers fitted with volume controls to adjust the broadcast to suit the background of noise to be overcome. Programmes will be radiated on both day and night shifts, and operated from the A.R.P. central control room. The company's directors feel certain that musical broadcasts in the works will relieve the monotony and assist in combatting any depression arising through working long hours in black-out conditions, which will be more marked during the approaching winter months. A record will be kept to indicate as near as possible the effects of these broadcasts in increased efficiency or maintained or increased output.

SPECIAL ALLOY IRON CASTINGS FOR CRANE BRAKE WHEELS.—As a result of recent experimental work carried out by the Meehanite Research Institute, working in co-operation with the Meehanite foundries in the United States, it is now possible to supply heavy-duty crane brake wheels from 21in. to 27in. diameter in G.A. Meehanite, which has a tensile strength of at least 50,000 lb. per square inch and a Brinell hardness of 220. It is claimed that inspection of such wheels in service has shown that they possess improved freedom from distortion and are highly resistant to glazing.

SCHEDULE OF RESERVED OCCUPATIONS.—The Ministry of Labour and National Service announces that technical laboratory assistants (aero-engine production and development, test observing, and analysis) are now reserved from the age of eighteen; research technical assistants (aero-engines), from the age of twenty-one; and miscellaneous engineering and metal trades (including shipbuilding) workers (sand blaster, sanding machine operator, sander), from the age of thirty. These amendments are not retrospective in their effect, that is, they do not involve the release of men now in the Forces or of men who have already received enlistment notices.

AIR RAID PRECAUTIONS TRAINING.—The second of the Air Raid Precautions Training Bulletins which the Ministry of Home Security is issuing is now available at the Stationery Office. These bulletins are issued for the benefit of instructors, and more particularly those in commercial and industrial establishments who have not the same opportunities for keeping in touch with the latest developments in A.R.P. matters as have local authorities' staffs. They contain all the latest information on all A.R.P. subjects, and all instructors are recommended to place a standing order with the Stationery Office for the further bulletins which will be issued from time to time.

THE MODIFICATION OF ALUMINIUM-SILICON ALLOYS.—A new booklet of 18 pages, with 11 plates, has been issued by the British Aluminium Company, Ltd., with the object of helping founders in the use of aluminium-silicon alloys. It has been found in the past that quite a large percentage of founders using these alloys, in particular British Standard Specification L.33, sooner or later run into difficulties. In most cases the complaint is found to be due to faulty modification technique. Over a period of years the company has investigated a very large number of difficulties connected with modification, and has also carried out a considerable amount of research on the subject, and in the new booklet it presents the results of both practical and laboratory investigations. Copies of the booklet may be obtained from the company's temporary head office, Shrewsbury, Shropshire.

WORKMEN'S COMPENSATION.—Under the Workmen's Compensation (Supplementary Allowances) Act passed this session, workmen who are entitled to weekly payments of compensation under the Workmen's Compensation Acts in respect of an accident which happened on or after January 1st, 1924, are entitled as from Monday, August 19th, to increased benefits. In the case of total disability (male or female) there is a supplementary allowance of 5s. a week in every case, and in the case of a male workmen there are allowances for children under fifteen years of age at the rate of 4s. a week for each of the first two children and 3s. a week for each additional child. Where the workman is only partially disabled and therefore earning or able to earn something less than his pre-accident wages, the allowances are scaled down so as to bear the same proportion to the full rates as his partial disability weekly payment to which he would be entitled if he were totally disabled. The total amount of the weekly payment and allowances is not to exceed in cases of total incapacity seven-eighths of the average weekly earnings of the workmen before the accident, and in cases of partial incapacity, seven-eighths of the difference between the pre-accident and post-accident earnings. Supplementary allowances are payable for illegitimate, step-children, and adopted children. It is estimated that additional allowances will mean an increase of about 30 per cent. in the total amount of compensation payable under the Acts, which will amount to about £9,000,000 a year.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

North of England Institute of Mining and Mechanical Engineers

Saturday, August 24th.—Neville Hall, Newcastle-upon-Tyne. Annual General Meeting. 2.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

CONCRETE, Ltd., London, and Leeds, informs us that in order to meet the increased demand for pre-cast concrete products for service huts and A.R.P. shelters, it has opened a new factory. Since the war began the firm has already opened two new factories, in addition to extending very considerably its previously existing works.

HIGH DUTY ALLOYS, Ltd., announces that Mr. H. G. Herrington, Mr. S. Sanders, and Mr. W. E. Prytherch have been elected to the board of the company. Messrs. Herrington, Sanders, and Prytherch occupy positions as general manager, personal assistant to the managing director, and chief metallurgist respectively.